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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 16.

# LEGUMINOUS PLANTS

FOR

# GREEN MANURING AND FOR FEEDING.

BY

E. W. ALLEN, Ph. D.,
ASSISTANT DIRECTOR OF THE OFFICE OF EXPERIMENT STATIONS.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

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## LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
*Washington, D. C., March 30, 1894.*

Sir: I have the honor to transmit herewith for publication as a Farmers' Bulletin an article on the value and use of leguminous plants for green manuring and for feeding, prepared under my direction by E. W. Allen, ph. d., assistant director of this Office. The scientific investigations in this country and abroad on the assimilation of nitrogen of the air by leguminous plants and the practical experiments with numerous varieties of these plants in the fields and in the stables of experiment stations, as well as by progressive farmers, have more definitely established the importance of these crops in maintaining or increasing the fertility of our agricultural lands and in providing our live stock with well-balanced rations. The résumé of this subject from the standpoint of advanced theory and practice, which this article contains, can in my judgment be usefully distributed in all sections of our country.

Respectfully,

A. C. True,
*Director.*

Hon. J. Sterling Morton,
*Secretary of Agriculture.*

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# LEGUMINOUS PLANTS FOR GREEN MANURING AND FOR FEEDING.

## GREEN MANURING.

Green manuring, or plowing under green crops raised for that purpose, is one of the oldest means of improving the fertility of the soil. It was advocated by Roman writers more than two thousand years ago, and from that time until now it has formed a most important resource of the farmer, especially where the supply of barnyard manure is insufficient. Its advantages are many. The more striking are that it furnishes the surface soil with a supply of the fertilizing materials needed by crops, increases the humus, and improves the physical qualities and the tilth of the soil. As a humus-former green manuring stands next to barnyard manure.

By means of green manuring, land which is practically barren may be brought up to a state of fertility where it will produce profitable crops. As a single instance of this may be mentioned the experiments carried on by the Michigan Experiment Station on the "Jack-pine plains" of that State. In 1888 experiments were undertaken on the light sandy, almost barren, soils of these plains. Green manures were used mainly, supplemented by cheap fertilizers. In three years marked improvement was evident, not only in the physical character of the soil, but also in the increased yields of various crops.

Again, green manuring may be used to take the place of more expensive fertilizers and manures on soils already under cultivation. It is in this latter use that it finds its widest application.

There has been much speculation as to the manner in which the crops commonly used for green manuring could gather such large quantities of fertilizing materials. It will be remembered that the principal fertilizing ingredients required by plants are nitrogen, phosphoric acid, and potash. These are each and all more or less essential to the healthy growth of crops. Consequently they are applied to the soil in the form of commercial fertilizers and other manures. In attempting to explain how the fertility of the soil is maintained by green manuring it has been said that plants with long roots, like clovers, feed deep down in the soil or subsoil on materials beyond the reach of surface-feeding plants; and that when the tops of these plants die down and are mixed with the surface soil they enrich it much the same as an application of barnyard manure. This is undoubtedly true, but it fails to explain how such large quantities of materials can be obtained, especially when clover is grown continuously for a number of years. The question has finally been solved by one of the most interesting and important discoveries yet made in agricultural science. It has been found that certain plants can feed upon the nitrogen in the atmosphere and store it up in their tissues as they grow. They take their phosphoric acid and potash from the soil, but they obtain their nitrogen very largely from the air. Hence they draw from the air a material necessary to the growth of crops, which in the form of commercial fertilizers, as nitrate of soda, ammonium sulphate, dried blood, etc., is paid for at the rate of from 15 to 20 cents a pound.

### HOW PLANTS GET NITROGEN FROM THE AIR.

The air we breathe is about four fifths nitrogen and one fifth oxygen. We use the oxygen in breathing but discard the nitrogen. It has been regarded merely as a material for diluting the oxygen, which would otherwise be too strong for our use. All attempts to economically render this nitrogen of the air available for plant food, by chemical means, have been unsuccessful. Recently it has been discovered that the so-called leguminous plants—clovers, peas, beans, lupines, vetches, etc.—can take up this nitrogen of the air, and can grow without being manured with nitrogen if manured with phosphoric acid and potash.

The manner in which this nitrogen assimilation takes place has been carefully and patiently studied by scientists, and although the details are not fully understood the primary cause has been found. It is believed that plants are enabled to get this nitrogen through the activity of the lower forms of life, bacteria or microbes, which can only be seen with the aid of a powerful microscope. These organisms live in the soil and are to be found where leguminous plants have been grown. They produce or cause the plant to produce little nodules, or tubercles, on the roots. It is through these tubercles that the plant gets its atmospheric nitrogen. The air enters the soil by the numerous pores or openings in it, which are produced by plowing, cultivating, and working the soil, by the decay of rootlets, by earthworms, etc. By just what physiological processes the nitrogen assimilation takes place is a question still in dispute among scientists. It is sufficient for practical purposes to know that nitrogen is taken up from the air by the growing plant, directly or indirectly; and that this nitrogen assimilation takes place as a result of the life of bacteria. It is a peculiar fact that few, if any, root tubercles are formed when leguminous plants are manured with nitrogen; the plants must first hunger for nitrogen before the tubercles are formed, and the presence of tubercles indicates that the plant is taking nitrogen from the air.

Now, curious as it may seem, there appear to be different forms of bacteria for different kinds of plants. Hence it sometimes becomes necessary to provide crops with the necessary bacteria before they can use the nitrogen of the air. This is done by applying a light dressing of soil in which the kind of plants it is wished to grow have been previously grown. This is called soil inoculation. It is sometimes necessary in growing a crop on a piece of land for the first time in several years. Suppose, for instance, that peas which had been sown on land manured with phosphates and potash but without nitrogen failed to grow luxuriantly. If the other conditions were favorable, the inference would be that bacteria of the right kind were lacking in the soil, and a light dressing of soil in which peas had previously been successfully grown might be applied. Such treatment as this has been repeatedly tried with success on a large scale.

These discoveries throw a new light on green manuring and on the plants best adapted for green manuring. They recommend it more highly than ever before as a soil renovator and a cheap means of maintaining the fertility of a soil. They show that while both leguminous and non-leguminous plants enrich the soil alike in humus-forming materials, in proportion to the size of the crop, they differ in respect to the source of their nitrogenous materials. While non-leguminous plants derive their nitrogen supply almost exclusively from the soil, leguminous plants may take theirs largely from the air. Consequently, if spurry, buckwheat, mustard, etc. (non-leguminous plants), are grown on the soil and the crop plowed in, the soil is not materially enriched in nitrogen; the process is simply returning to the soil all the nitrogen which the crop took from it. But since leguminous plants may derive the larger proportion of their nitrogen from without the soil—that is, from the air—their use for green manuring actually enriches the soil in nitrogenous matter.

It will thus be seen that by green manuring with leguminous crops it is possible to manure the soil with nitrogen from the air, a free and inexhaustible source, and thus avoid buying fertilizers containing much nitrogen. This greatly lessens the expense for commercial fertilizers, for nitrogen is the most expensive element the farmer has to buy. As stated above, it costs from 15 to 20 cents a pound, while potash and phosphoric acid cost only 5 to 7 cents, or even less. Although grains, grasses, corn, cotton, root crops, tobacco, etc., can not use the nitrogen of the air, green manuring enables them to benefit by it indirectly.

## SOME CROPS FOR GREEN MANURING.

Among the leguminous plants more commonly used for green manuring in this country and in Europe are cowpea, alfalfa, clovers, melilotus, serradella, lupines, vetch, and horse bean. Some of these are described below.

### COWPEA.

The cowpea is widely used as a green manure in the Southern States. According to the North Carolina Experiment Station, "the cowpea, being a tender annual, should always be sown in the spring. It will give a good yield sown as late as July 1, but the earlier it is sown after danger of frost is passed the heavier the yield. The pea is usually sown broadcast at the rate of 2 bushels per acre and plowed or harrowed in. The cowpea is not affected by heat, and is less sensitive to drought than any of the clovers."

Experiments have shown that cowpeas respond readily to applications of potash and phosphates, and are able to derive their nitrogen very largely from the air. Inasmuch as cowpeas are large gatherers of nitrogen, and also secure considerable amounts of potash and phosphoric acid through their extensive root system, which reaches down to the subsoil, they have a high fertilizing value. How to get the greatest benefit from the fertilizing constituents of cowpeas is one of the problems on which the experiment stations are working. If the cowpeas are plowed under in the fall and the ground left bare until spring a large share of the nitrogen will be leached away. By sowing wheat or rye after the cowpeas are plowed under part of this loss may be avoided. If the vines are cut and allowed to lie on the ground during the winter the nitrogen is rapidly lost. In an experiment at the station in Alabama it was found that vines gathered in October had from 1.45 to 2.62 per cent of nitrogen, while if left on the ground until January they had only about 0.70 per cent, *i. e.*, they lost two thirds of their most valuable fertilizing ingredient.

Experiments at the Louisiana station show that 1 acre of cowpeas, yielding 3,970.38 pounds of organic matter, turned under, gave to the soil 64.95 pounds of nitrogen, 20.39 pounds of phosphoric acid, and 110.56 pounds of potash, of which at least 8.34 pounds of nitrogen, 4.43 pounds of phosphoric acid, and 18.1 pounds of potash were furnished by the roots. Analyses made at the South Carolina Station show that cowpea hay contains 1.42 per cent of potash, 0.39 per cent of phosphoric acid, and 2.71 per cent of nitrogen. Cowpea roots contained 1.19 per cent of potash, 0.28 per cent of phosphoric acid, and 0.94 per cent of nitrogen; the roots and stubble, two months after the crop was harvested, contained 0.83 per cent of potash, 0.26 per cent of phosphoric acid, and 1.35 per cent of nitrogen. Experiments elsewhere showed that the vines from a given area weighed six times as much as the roots, and were 8⅓ times as valuable for manure.

Cowpeas and melilotus have given good results as green manure on the canebrake lands of Alabama. "Before the land was sowed in melilotus and cowpeas it was not considered worth cultivating. This season (1890) it produced as fine a crop as the best lands of the station highly fertilized."

### ALFALFA.

Alfalfa or lucern has long been cultivated in Europe, and is grown quite extensively in some of the Western and Southern States. It seems probable that it may be introduced with advantage into many parts of the Southern States east of the Mississippi, and over a wide tract of the more arid regions of the Southwest. Under favorable conditions it will live from eight to fifteen years, and does not run out as clover does. It has been grown successfully for seven years at the experiment station at Geneva, N. Y., but in recent experiments on 30 farms in different parts of Vermont it was very largely winterkilled. While a Southern climate is more favorable to alfalfa, numerous experiments have shown that it will do well in many localities in the Northern States, and when established will produce from three to five crops each season for a number of successive years. Alfalfa is said to be especially adapted to dry climates, and withstands drought much better than ordinary clovers. For this reason it is largely relied on in Colorado and California, especially where irrigation is used.

The value of alfalfa for green manuring has been quite thoroughly studied by the New Jersey Experiment Station. Seed was sown broadcast at the rate of 15 pounds per acre. A fertilizer containing phosphoric acid and potash with a little nitrogen was applied. It appears from these studies that alfalfa derives nitrogen from some other source than the soil, and draws potash through its long roots from the deeper layers of the subsoil. In three years 90 pounds of nitrogen per acre was applied in the fertilizer, and the crops harvested in that time contained 912.8 pounds of nitrogen per acre. The fertilizing materials contained in the crops harvested in four years are shown in the following table:

*Fertilizing ingredients in alfalfa during different seasons.*

| Year. | Pounds per acre. | | |
|---|---|---|---|
| | Nitrogen. | Phosphoric acid. | Potash. |
| 1886 | 261.6 | 39.6 | 203.5 |
| 1887 | 253.6 | 45.7 | 286.9 |
| 1888 | 299.2 | 52.4 | 292.2 |
| 1889 | 360.0 | 63.0 | 255.5 |

The average of the above table is 304 pounds of nitrogen, 50 pounds of phosphoric acid, and 260 pounds of potash a year. These amounts would be furnished by a dressing of 1,900 pounds of nitrate of soda, 500 pounds of muriate of potash, and 300 pounds of South Carolina superphosphate. The phosphoric acid and potash were naturally derived from the soil. The 300 pounds of nitrogen would cost in the form of nitrate of soda, at the present low price of 15½ cents a pound, $46.50.

### RED CLOVER.

Red clover has been cultivated for centuries. It succeeds best in a temperate climate not deficient in moisture. In the central and eastern part of the United States it constitutes one of the most important hay crops. Though not generally grown in the Gulf States it succeeds on the strong clay lands and black prairie soil of the South. It may be grown as far north as Minnesota, but frequently does not thrive in newly settled sections. It has been successfully grown all over Nebraska, where it is recommended for early pasture as well as for hay, and where it withstands drought. It has proved valuable in South Dakota. Most of the experiment stations give favorable reports of this plant. In Nevada, however, without water the growth is light.

As a green manure it is perhaps more extensively used in the United States than any other plant. Twenty pounds of seed per acre is the quantity usually recommended. The seed is frequently adulterated with weed seed. At the Mississippi Station light-colored and dark seed germinated alike in the ground. Clover is sown broadcast. In cold climates spring sowing is customary. The Connecticut Storrs Station recommends sowing after grain in the latter part of July, in order to secure an early crop the next season. In the South seeding in September or October and in February is successful. In Kentucky seed sown between February 2 and March 1 nearly all germinated.

Studies of the root system of red clover grown at the Minnesota Station showed that the amount of roots and the depth to which they penetrate vary greatly, depending on the character of the land. In a favorable soil a plant one month old had a root extending 7 inches into the ground; at two months old it had reached a depth of 2 feet; at five months its length was 5 feet 8 inches. The root development is most extensive on drained land. The stand is also better on drained than on undrained soils.

### CRIMSON CLOVER.

Crimson clover, also called scarlet clover and Italian or German clover, grows from 1 to 2 feet high, with flower heads from 1½ to 2 inches long and of a bright crimson color. Though not generally grown in the North it made a growth of 26 inches at the Maine Station. It thrives on soil too light for other clovers. In the South it is valuable on non-calcareous, sandy, or light clay soils. It has been highly recommended for green manuring and its value for that purpose has been studied especially by the Delaware Experiment Station. That station reported that in 1891 2,340 acres of crimson clover were grown in Delaware, 1,277 acres being used for green manuring. It is sown both in the open field and in orchards. The quantity of seed used depends upon the aims of the sower, varying between 5 and 15 pounds per acre. It is also sown among corn, and with a broadcasting machine 4 acres per hour can be seeded. It may be grown either as a winter crop, covering the soil during September, October, and November, or as a summer crop As a winter crop it may either precede or follow the Southern cowpea vine. In Delaware a very large acreage of field corn is sown to crimson clover immediately after the cultivation of the corn is finished for the season.

Crimson clover is sown in Delaware the latter part of July or during August. In the South the seed may be sown from August till the middle of September or even later in extreme southern latitudes. It is important that considerable growth should be made before winter. On the other hand, to obtain a good stand, one must wait for a suitable season. It is not necessary to prepare the land especially for the clover crop, but the seed may be sown in fields of cotton, corn, or vegetables immediately after the cultivation and without covering. If clover is the only crop a light brushing or rolling is in order. The seed may also be sown among the vines of a pea crop. Crimson clover begins its growth as the peas die, and these two renovating crops supply a very large amount of organic matter to the soil.

Failure to secure a stand of crimson clover is frequent, due sometimes to the seed and sometimes to the season. The newly germinated plants are easily killed by a scorching sun. On stubble land a catch may be secured by harrowing deeply and then sowing the seed and rolling or harrowing lightly.

In Delaware crimson clover can be cut for hay or for silage early in May. In the South it blooms in April. A yield of from 1 to 2 tons of excellent hay may be secured from very thin land. The hay is taken off in time to allow the use of the field for other summer crops. In Delaware some farmers, while plowing under the green crop in orchards, turn the furrows so as to leave the heads of clover above ground. These heads bear seed and thus afford a stand the next year. In cutting for hay in orchards other farmers leave strips of uncut clover along the rows of trees. From these strips the seed is scattered for the next year's crop.

Crimson clover may follow grain or grass as well as cultivated crops. After cultivated crops it usually makes a good catch with slight expense. Orchards on thin soils may be benefited by plowing in crimson clover for several years in succession. On rich soil and for some crops it is possible to incorporate too much organic matter with the soil. Crimson clover leaves the land in good condition for a crop of cotton, corn, or vegetables. It has been found an excellent substitute for nitrate of soda in growing sweet potatoes in Delaware.

At the Delaware Experiment Station crimson clover yielded at the rate of 13 tons 566 pounds of green material per acre (exclusive of roots and stubble), containing 131 pounds of potash, 35 pounds of phosphoric acid, and 115 pounds of nitrogen. As a source of nitrogen for fruits, field crops, and vegetables it has given highly satisfactory results, in some cases surpassing nitrate of soda.

The following illustration of the result of using crimson clover for green manuring is from a recent report of the Delaware Experiment Station:

> Seed of crimson clover costing $1 per acre was sown in a corn field near Newark, in 1891, immediately after the last cultivation of the crop. The clover passed out

of blossom during the first week of June, 1892. A test made at that time indicated that the green crop then standing weighed 8 tons 600 pounds per acre. It was plowed under on the 5th instant; Mastodon seed corn was planted on the 7th. An adjoining plat upon which tomatoes had been grown in 1891, and upon which no clover had been seeded for many years, was also planted with the same variety of corn on the 7th instant. A portion of this corn on the tomato plat was top-dressed with nitrate of soda, 100 pounds per acre, costing $1. The tomato plat yielded 24 bushels of shelled corn per acre, the tomato plat with nitrate of soda yielded 30 bushels, and the plat manured with crimson clover yielded 48 bushels.

Eight tons 600 pounds of crimson clover from seed which cost $1 per acre added 24 bushels to the corn crop. One dollar invested in nitrate of soda and used as a top-dressing added 6 bushels to the corn crop. Hence in this case $1 invested in clover seed returned four times as much as $1 invested in nitrate of soda. As to the relative amount of labor involved the sowing of the seed and the broadcasting of the nitrate possibly balance each other. Plowing down a green crop is doubtless far more costly than plowing bare ground. This drawback may reduce the above-named apparent gain by approximately 25 per cent.

## JAPAN CLOVER.

Japan clover (*Lespedeza striata*) has been very successfully grown at the North Carolina Experiment Station and is strongly recommended as a renovator of worn soils. At the station it was grown on a very poor stiff clay soil with a light dressing of phosphate. Other clovers, lucern, and serradella, did very poorly on this soil, but the Japan clover presented a most luxuriant appearance throughout the season. The seed is broadcasted at the rate of about 12 pounds per acre and covered with a smoothing harrow or roller. The seed costs from 12 to 20 cents a pound, and can be bought of most of the larger seed firms. The seed should be sown in the spring after danger of frost is over, as the plant is very tender. Japan clover seems to prefer a moist clay soil, but does well on almost any soil except pure sand, and thrives without fertilizer on exhausted soils. Drought checks its growth for a time, but not seriously.

The North Carolina Station says:

> The ability to grow on land too poor to produce even broom sedge, and to crowd out all other plants; its dying each winter and leaving its roots to fertilize the soil; and its possessing the nitrogen-fixing power peculiar to the pulse family of plants, place Japan clover at the head of renovating plants adapted to the climate of Southern States. It is unequaled as a restorer of worn fields, such as are generally turned out to grow up in pines.

## LUPINES.

The three species of lupines more commonly grown are the white, the yellow, and the blue lupine. The plants are bushy, somewhat woody, and generally too coarse for good fodder, though they are used in some countries for sheep. The seed is exceedingly nitrogenous and in Europe is used for cattle food. As it contains a bitter alkaloid injurious to animals it must be disembittered before feeding. Kellner's process of disembittering lupine seed consists in soaking the seed in water for twenty-four hours, with frequent changes of water, steaming for one hour, and then extracting for two days, with frequent stirring. In the latter operation the discolored water is drawn off frequently and fresh water added. Five pounds daily of this disembittered lupine seed may be fed to cows per 1,000 pounds live weight.

Lupines are much used in Europe for green manuring. They thrive on a light sandy soil, make a rapid growth, and produce large amounts of organic materials, which when plowed into the soil improve it in humus and enrich it in nitrogen. A practice recommended for bringing up very poor soils is to grow a crop of lupine manured with kainit, turn the crop under, and follow it with winter rye manured with Thomas slag phosphate.

In order to derive the greatest possible advantage from the green manuring, the lupines should be sown early in May. By the first half of August, which is believed to be the best time of the year for plowing under, the seed of the lupine will be nearly or quite formed, and the crop will contain the maximum quantity of nitrogenous matter. Four, or better six, weeks should intervene between the plowing under of the lupine and the sowing of the rye.

Under such a rotation a poor sandy soil will gradually improve in humus until the change is perceptible to the eye in the darker color of the soil, and there will likewise be an increase in fertility.

In Europe large tracts of barren waste have been brought into condition for profitable cultivation by green manuring with lupines treated with phosphates and potash salts.

### COMPOSITION OF GREEN LEGUMINOUS CROPS.

The following table gives the average amounts of water and fertilizing materials in 100 pounds in a number of green leguminous crops:

*Fertilizing ingredients in 100 pounds of green leguminous crops.*

| | Moisture. | Nitrogen. | Phosphoric acid. | Potassium oxide. |
|---|---|---|---|---|
| | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Red clover | 80.00 | 0.53 | 0.13 | 0.46 |
| White clover | 81.00 | 0.56 | 0.20 | 0.24 |
| Alsike clover | 81.80 | 0.44 | 0.11 | 0.20 |
| Crimson clover | 82.50 | 0.43 | 0.13 | 0.49 |
| Alfalfa | 75.30 | 0.72 | 0.13 | 0.56 |
| Cowpea | 78.81 | 0.27 | 0.10 | 0.31 |
| Serradella | 82.59 | 0.41 | 0.14 | 0.42 |
| Soja bean | 73.20 | 0.29 | 0.15 | 0.53 |
| Horse bean | 74.71 | 0.68 | 0.33 | 1.37 |
| White lupine | 85.35 | 0.44 | 0.35 | 1.73 |
| Yellow lupine | 83.15 | 0.51 | 0.11 | 0.15 |
| Flat pea (*Lathyrus sylvestris*) | 71.60 | 1.13 | 0.18 | 0.58 |
| Common vetch | 84.50 | 0.59 | 1.19 | 0.70 |

### GREEN MANURING COMPARED WITH FEEDING THE CROP.

In spite of the many advantages of green manuring, there are conditions under which it can not be regarded as a rational and profitable practice. It involves the absolute waste of large quantities of the very best kind of fodder. For this reason green manuring on good soils can only be recommended when the conditions of farming do not admit of the careful preservation of manure. The crops should be fed to animals and the manure carefully saved and returned to the soil. It is in this manner only that the full value of the crop can be secured. By feeding the crop this animal food is saved, and at the same time from three quarters to nine tenths of the fertilizing materials (nitrogen, phosphoric acid, and potash) in the crop may be returned to the soil in the manure, if this is properly cared for. Animals need for their nutrition nitrogen, fat, and carbohydrates (starch, sugar, etc.). The nitrogen in foods is in the form of protein (albuminoid materials). It is the same nitrogen which in green manuring enriches the soil. These leguminous crops are unusually rich in protein—far richer than most other coarse fodders. For instance, while hay from grasses contains from 6 to 8 per cent of protein, red clover hay contains 12.5 per cent, alfalfa hay 14.3 per cent, and cowpea hay 16.6 per cent of protein. If grass hay and corn are fed, such concentrated feeding stuffs as cotton-seed meal, gluten meal, linseed meal, etc., must be fed to make up the supply of protein needed. If leguminous crops are fed, much less grain will be required.

As nitrogen is the most expensive fertilizing element, so protein (nitrogen) is also by far the most expensive food element. By feeding the leguminous crops instead of plowing them under a twofold result is secured—animals are nourished without buying expensive grain feeds, and the soil is enriched to very nearly the same extent as in green manuring.

Beyond question the nitrogen of the air, which is obtained without cost through the agency of leguminous plants, is best utilized in improving the productiveness of the land and increasing the profits of the farm when it is used in the production of milk and meat and thereby in the production of cheap barnyard manure. What has been said of the nitrogen applies also to the carbohydrates and fats which the plant derives from the carbonic acid of the air. If the crop is fed, the carbohydrates and fat serve to nourish the animal and a portion in turn passes into the barnyard manure, and when applied to the soil has a favorable effect on the humus formation. This is the true economy of material. It is following out the law of nature. Its profitableness will depend upon the price of feeding stuffs in general. The higher the prevailing price of hay and other feeding stuffs the larger will be the profit from feeding the crop rather than using it for green manuring. Let us consider a few examples of the value of a crop for green manuring and for feeding on different kinds of soils.

### SERRADELLA ON MEDIUM SANDY SOILS.

Take, for instance, the case of serradella on the better class of sandy soils. This plant does well on medium light sandy soils. It may be sown among winter rye in spring. Under these conditions it produces an unusually luxuriant vegetation which may either be plowed under with good effect on the crop following, or it may be pastured. Serradella is an excellent fodder plant and may be fed with none of the danger attending the feeding of lupines. It may be fed either green or as hay or silage. It is eagerly eaten by all kinds of farm animals, retains its palatability and food value up to the end of blooming, and has a very favorable effect on the secretion of milk.

The claim is frequently made, in advocating growing serradella for green manuring, that it is an exceedingly cheap means of securing nitrogen; that with a small expenditure for seed, and no extra labor except that of sowing the seed, a large amount of nitrogen is secured from the air. Admitting this, has not this nitrogen, in the form in which it exists, namely, as protein, a much higher value when used for feeding animals than when plowed under? If it is a cheap source of nitrogen for manuring, is it not also a cheap source of protein for feeding, especially when three quarters of the nitrogen in the crop is recovered in the manure?

A German authority on feeding and farm management has calculated the matter on a financial basis. Assuming an average crop of 17,600 pounds of green serradella, which is a moderate crop, he finds the nitrogen in the crop from an acre to be worth $11.06. This is taken as the value of the crop for green manuring, as the nitrogen is the only fertilizing element not derived from the soil, and the barnyard manure furnishes nearly as much humus as green manuring.

The estimated profit from feeding the crop of 17,600 pounds of green serradella to milch cows, when the barnyard manure is returned to the soil, is $23.12. In this calculation every possible expense attending the feeding is taken into account, including care of animals, interest on money, cost of carting the barnyard manure to the land, etc., and allowance is made for the phosphoric acid and potash sold in the milk. The comparison stands then as follows:

| | |
|---|---|
| Profit from feeding crop of serradella from 1 acre................ | $23.12 |
| Value of crop of serradella from 1 acre for green manuring...... | 11.06 |
| Difference ............................................. | $12.06 |

This calculation shows the crop of serradella to be more than twice as valuable for feeding as for green manuring.

The above calculation assumed a daily milk yield of 7½ quarts, sold at 2¼ cents per quart. On the basis of only 1½ cents per quart of milk, the feeding value would be $13.52, or still $2.46 higher than the value for green manuring.

## GREEN MANURING ON MEDIUM RICH SOILS.

Green manuring on medium rich soils has much less to recommend it than on sandy soils. Although the green manuring of light sandy soils with lupines is often of very great advantage in enriching the soil in humus, this advantage does not hold good in the case of better soils.

There are other plants better adapted than lupines to serve as fallow crops on these better soils. Serradella does well, but as a rule is not to be recommended for a principal crop, and when sown with rye, giving a good yield, it is often so choked out as to amount to very little. But where it can be grown with advantage as a first crop on better soils it must be fed to be utilized to the fullest extent, as pointed out above.

Peas and vetch are especially adapted for fallow crops, and can be recommended for green manuring. But as they are also good fodder plants, all that has been said above regarding this subject applies to them with equal force.

An experiment of interest in this connection was made at the Agricultural Institute at Halle, Germany, in 1891. About 3 acres of land was used which had been in winter wheat in 1890 and in winter rye in 1891. A mixture of 194 pounds of white field peas, 44 pounds of common sand vetch, and 35 pounds of yellow lupine seed per acre was sown August 11. The crop was plowed under October 28. A good growth had been made and the crop was fitted either for green manuring or for feeding. The yield was at the rate of 8,650 pounds of green material per acre. This contained by analysis 0.575 per cent of nitrogen, or 49.74 pounds of nitrogen per acre, which at 15 cents per pound gave a value for the crop for green manuring of $7.46 an acre.

In the spring of 1892 white pearl barley was sown on the whole area and also on an adjoining piece not green manured. The crops were harvested August 18, with the following results per acre:

*Yield of barley per acre with and without green manuring.*

| | Grain. | Chaff. | Straw. |
|---|---|---|---|
| | *Bushels.* | *Pounds.* | *Pounds.* |
| Plat green manured with peas, vetch, and lupine | 61.38 | 366 | 3,260 |
| Plat not green manured | 61.48 | 385 | 2,908 |

An effect of the green manuring is only noticeable in the amount of straw, which is larger by about 350 pounds per acre where the mixture of peas, vetch, and lupine had been plowed in.

The barley crop from the green-manured plat contained 68.56 pounds of nitrogen per acre, and that from the plat not green manured 56.6 pounds of nitrogen. This difference of 11.96 pounds of nitrogen is nearly all accounted for by the nitrogen contained in the seed sown on the green-manured plat, so that it may be that on this medium rich soil green manuring was without any effect whatever on the crop immediately following it. The pea and vetch plants produced root tubercles, and it is probable that had the plants been allowed to fully develop and ripen the effect of the tubercles would have been much more apparent in the t of nitrogen in the crop plowed under. But the richer the soil larger the proportion of nitrogen which will be taken from the d the less from the air. This nitrogen-gathering appears to go t in a soil deficient in available nitrogen, as already mentioned. author estimates the green forage as worth $3 per ton for feed- hich would make the crop worth $13 per acre, or $5.54 more per han the estimated value for green manuring.

### GREEN MANURING ON SANDY LOAM SOILS.

mpared with the above green-manuring trial on medium rich soil, esult was quite different in a similar trial in 1891 on a sandy loam oor in humus. A piece of land which for many years had received rm cropping and manuring was divided into two plats of about fourth acre each. Rye had been grown on both plats that season. ne plat white field peas were sown in the rye stubble August 15. other plat was given the same preparatory treatment, but remained . Both plats were plowed November 2. The pea vines had grown height of 15 to 18 inches, and a large weighed sample showed that green crop was at the rate of 3½ tons per acre, containing 37⅓ nds of nitrogen.

arch 23, 1892, barley was sown on both plats. The green-manured received no other manuring, but the other plat received an amount itrate of soda furnishing 28 pounds of nitrogen per acre. The ey was harvested August 9. The yield on the two plats was practlly the same. The agreement in percentage of nitrogen is equally cing. The total nitrogen per acre in the crop from the green-ured plat was 60.34 pounds, and from the nitrate of soda plat 60.12 nds. The green manuring, with 37.33 pounds of nitrogen per acre, given a result equally as good in every way as an application of 28 nds of nitrogen per acre in the form of nitrate of soda. But even this favorable result there was no financial advantage from the n manuring as shown by this single crop. It furnished 37.33 pounds itrogen per acre, which at 15 cents per pound would be worth only 0, which would no more than pay for the pea seed used.

### ALFALFA AND CRIMSON CLOVER FOR FEEDING.

uppose that, instead of being plowed under, the alfalfa grown at the Jersey Experiment Station, as referred to (p. 9), had been fed to nals and the manure carefully saved and returned to the soil. The l yield of four cuttings during the season of 1889 was about 23 tons reen alfalfa per acre. The value of this crop for fodder at $3 per would be $69 as compared with its value of $46.50 for green manur. , and it is fair to assume that some $35 worth of nitrogen would returned to the soil in the manure. The crop of 13¼ tons of crimson-ver reported elsewhere (p. 11) would be worth about $40 for feeding as npared with $17.25 for green manuring When made into [illegible] account there was little or no profit from the operation. If the manure was valued at current rates for fertilizing materials a fair profit was apparent.

### ADVANTAGES OF SOILING.

The advantages of soiling, or feeding animals largely or wholly on green forage crops in the barn instead of pasturing them, are that less land is required to maintain a given number of animals, the food supply can be better regulated, the animals do not waste their energy in searching for food, and the manure can all be saved and applied to the soil. The arguments for partial soiling are that the amount of feed furnished by pastures is very irregular, being usually abundant and of good quality early in the season, but falling off later from droughts or early frosts. In the case of milch cows unless some supplementary food is given at such times the milk flow diminishes and the cows fall off in flesh.

Concerning the relative amounts of food furnished by pasturing and by soiling, the Pennsylvania Experiment Station found in experiments in two years that "in round numbers we can produce from three to five times as much digestible food per acre by means of the soiling crops (rye and corn or clover and corn) as is produced by pasturage such as is represented by our small plat." The plat in question was believed to fairly represent the average pasture. From feeding trials with the above soiling crops and pasture grass the average yield of milk per acre was calculated as follows:

*Yield of milk per acre of land.*

| | 1888. | 1889. |
|---|---|---|
| | *Pounds.* | *Pounds.* |
| Soiling | 3,416 | 5,671 |
| Pasturage | 928 | 1,504 |
| Difference | 2,488 | 4,167 |

It will be understood that the above is partly an estimate, but it points very strongly in favor of soiling.

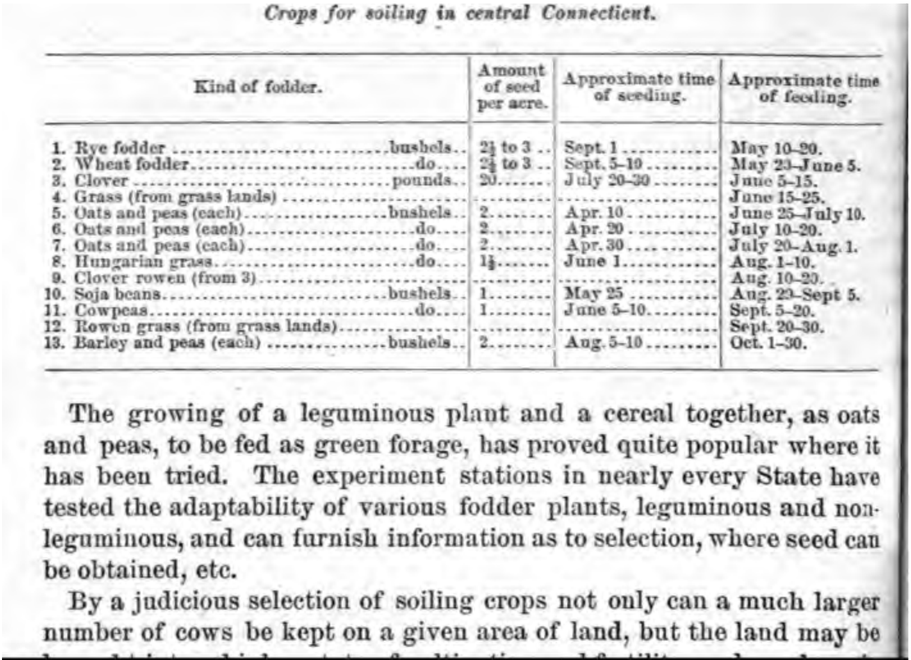
Trials at the station in Wisconsin showed that "by soiling in summer a certain area of land will yield double the amount of milk and butter that it will when pastured."

The Connecticut Storrs Experiment Station maintained 4 cows from June 1 to November 1 on a little less than 2½ acres of soiling crops with the addition of a very light grain and straw feed.

At the Ontario Agricultural College and Experimental Farm about three fourths of an acre of soiling crops (green clover, green peas, tares, oats, and corn fodder) was sufficient, with the addition of 252 pounds of wheat bran, for 2 cows for sixty-three days. "We might expect, therefore, to grow on about 1 acre sufficient green food to feed a cow for two hundred days under ordinary conditions."

If soiling is to be practiced it is important to have a succession of green fodders throughout the growing season, with each in its best stage of growth for feeding. There should be no breaks in the succession and each crop should be used as nearly as possible at the time when it contains the largest amount of valuable food constituents.

From three years of experience and observation in the practice of soiling, the Connecticut Storrs Station suggests the following series of crops for soiling in central Connecticut:



*Crops for soiling in central Connecticut.*

| Kind of fodder. | | Amount of seed per acre. | Approximate time of seeding. | Approximate time of feeding. |
|---|---|---|---|---|
| 1. Rye fodder | bushels | 2½ to 3 | Sept. 1 | May 10–20. |
| 2. Wheat fodder | do | 2¾ to 3 | Sept. 5–10 | May 23–June 5. |
| 3. Clover | pounds | 20 | July 20–30 | June 5–15. |
| 4. Grass (from grass lands) | | | | June 15–25. |
| 5. Oats and peas (each) | bushels | 2 | Apr. 10 | June 25–July 10. |
| 6. Oats and peas (each) | do | 2 | Apr. 20 | July 10–20. |
| 7. Oats and peas (each) | do | 2 | Apr. 30 | July 20–Aug. 1. |
| 8. Hungarian grass | do | 1½ | June 1 | Aug. 1–10. |
| 9. Clover rowen (from 3) | | | | Aug. 10–20. |
| 10. Soja beans | bushels | 1 | May 25 | Aug. 20–Sept 5. |
| 11. Cowpeas | do | 1 | June 5–10 | Sept. 5–20. |
| 12. Rowen grass (from grass lands) | | | | Sept. 20–30. |
| 13. Barley and peas (each) | bushels | 2 | Aug. 5–10 | Oct. 1–30. |

The growing of a leguminous plant and a cereal together, as oats and peas, to be fed as green forage, has proved quite popular where it has been tried. The experiment stations in nearly every State have tested the adaptability of various fodder plants, leguminous and non-leguminous, and can furnish information as to selection, where seed can be obtained, etc.

By a judicious selection of soiling crops not only can a much larger number of cows be kept on a given area of land, but the land may be hich is much richer in protein (nitrogen) than silage made from ne.

ltivation of these leguminous plants involves somewhat more a rule, than raising grass hay, but it is believed that it will ofitable for it enables the farmer to raise his own concentrated he same time that he raises his coarse fodder. For instance, a speriment has indicated that soja-bean meal is fully equal to ed meal for milk and butter production. This meal is one of st feeding stuffs we have. It exceeds linseed meal and gluten rotein (nitrogen) and far exceeds these and cotton-seed meal in s only surpassed in protein by cotton-seed meal and some of the little used in this country. The beans can be thrashed out and and the straw fed as coarse fodder. This straw is richer in terials than a good meadow hay. It contains 9½ per cent of while meadow hay averages about 7½ per cent. The cowpea treated in similar manner. The ground cowpeas are a richly ous feed, although not as rich as soja-bean meal; and the vines rly or quite equal to clover hay and far surpass grass hay in s.

ollowing table shows the average composition of hay from legu- crops as compared with hay from grasses:

*Average composition of hay from grasses and leguminous crops.*

| Hay from— | Water. | Protein. | Carbohydrates. | Fat. |
|---|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| | 8.9 | 7.9 | 76.0 | 1.9 |
| grass | 9.9 | 8.1 | 73.4 | 2.6 |
| | 13.2 | 5.9 | 74.0 | 2.5 |
| an grass | 7.7 | 7.5 | 76.7 | 2.1 |
| y blue grass | 15.0 | 8.2 | 78.1 | 4.4 |
| er | 15.3 | 12.3 | 62.9 | 3.3 |
| clover | 13.4 | 14.0 | 55.6 | 4.1 |
| over | 10.9 | 13.8 | 63.1 | 3.7 |
| lover | 9.7 | 12.8 | 66.3 | 2.9 |
| lover | 9.7 | 15.7 | 63.4 | 2.9 |
| | 8.4 | 14.3 | 67.7 | 2.2 |
| | 10.7 | 16.6 | 62.3 | 2.9 |
| la | 9.2 | 15.2 | 65.7 | 2.6 |
| | 8.4 | 14.5 | 67.8 | 2.1 |
| n | 6.3 | 14.5 | 66.6 | 5.6 |
| verage for grasses | 10.94 | 7.52 | 75.64 | 2.70 |
| verage for leguminous plants | 10.20 | 14.37 | 64.14 | 3.23 |

nay be said in general that 100 pounds of hay from leguminous contains about twice as much protein as 100 pounds of hay from es. The leguminous hay may be safely estimated as worth from urth to one third more for feeding than common hay. This is in spite of the fact that it does not usually command a higher in the markets, owing to certain prejudices against its use.

ssuming that the common grasses yield 2 tons of hay to the acre, and clovers, etc., 3 tons of hay, the amounts of food materials and tilizing materials in the crops are approximately as follows:

*Relative yield of food and fertilizing materials in crops of hay from grasses and leguminous crops.*

| Hay from— | Assumed yield per acre. | Food materials in crop per acre. | | | Fertilizing materials in per acre. | | |
|---|---|---|---|---|---|---|---|
| | | Protein. | Carbohydrates. | Fat. | Nitrogen. | Phosphoric acid. | Po |
| | *Tons.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Po* |
| Red top | 2 | 158 | 1,520 | 38 | 23.0 | 7.2 | |
| Timothy | 2 | 118 | 1,480 | 50 | 25.2 | 10.6 | |
| Red clover | 3 | 369 | 1,887 | 99 | 62.1 | 11.4 | |
| Alfalfa | 3 | 429 | 2,031 | 66 | 65.7 | 15.3 | |
| Cowpea | 3 | 498 | 1,869 | 87 | 58.5 | 15.6 | |
| Soja bean | 3 | 435 | 1,998 | 168 | 69.6 | 20.1 | |

The amount of hay produced on different farms varies so widely t it is difficult to strike an average, especially for the leguminous cro It will be seen that on the above basis, which is believed to be a f one, the leguminous crops furnish from two to four times as much p tein per acre as common grasses, together with much more fat a rather more carbohydrates. They also contain nearly three times much nitrogen and about twice as much potash. It should be reme bered that under favorable conditions they may draw a large prop tion of this nitrogen from the air, instead of depleting the soil, and th their long roots enable them to feed upon the potash deep down in soil beyond the reach of surface-feeding plants.

### SUMMARY.

(1) Green manuring improves the physical properties of the soil making the soil more porous and adding to its supply of humus. brings up the dormant plant food from deep down in the soil a deposits it near the surface, where it can be used by plants feeding ne the surface.

(2) Green manuring with buckwheat, Hungarian grass, and ot non-leguminous plants adds practically nothing to the soil which w not there before, except a mass of vegetable matter which decays a goes to form humus.

(3) Green manuring with clovers, peas, beans, lupines, etc. (legu nous crops), actually enriches the soil in nitrogen drawn from the a These plants can grow with very little soil nitrogen. They store the nitrogen of the air as they grow, and when plowed under give up to the soil and to future crops. It is the cheapest means of man ing the soil with nitrogen.

(4) But animals, as well as plants, require nitrogen for food. feeding the crops of clover, cowpea, etc., only about one fourth of t fertilizing materials of the crop is lost if the manure is properly car for. As the nitrogen of the air is the cheapest source of nitrogen

plants, so it is the cheapest source of protein (nitrogen) for animals. The leguminous crop is best utilized when it is fed out on the farm and the manure saved and applied to the soil. The greatest profit is thus secured and nearly the same fertility is maintained as in green manuring.

(5) For renovating worn or barren soils, and for maintaining the fertility where the barnyard manure is not properly cared for, green manuring with such leguminous crops as cowpea, clovers, and lupines is recommended. A dressing of potash and phosphates will usually be sufficient for the green manuring crop.

(6) The practice of green manuring on medium and better classes of soils is irrational and wasteful. The farmer should mend his system so that the barnyard manure will be as well cared for as any other farm product. Loss from surface washing, leaching, fermentation, and decay should be guarded against. Then the feeding of richer food will mean richer manure and better and cheaper crops.

(7) The system of soiling, or feeding green crops in the barn in place of pasturage, enables a larger number of animals to be kept on a given area of land, and the manure to be more completely saved. For this purpose leguminous crops are extremely valuable.

(8) Hay from leguminous crops is about twice as rich in protein as hay from grasses. In the one case this protein (nitrogen) is obtained very largely from the atmosphere; in the other it is all drawn from the fertility of the soil. Leguminous crops yield larger crops of hay to the acre than grasses. Hence the production of food materials on an acre, especially protein, is several times larger with leguminous crops.

(9) If allowed to ripen, the seed of the cowpea and soja bean furnishes an extremely rich concentrated feed which can be ground and fed in place of expensive commercial feeds. The straw remaining may be fed as coarse fodder, for it is richer than ordinary hay.

(10) Grow more leguminous crops. They furnish the cheapest food for stock and the cheapest manure for the soil. They do this because they obtain from the air a substance necessary for plants and animals alike, which costs in the form of fertilizers and feeding stuffs from 15 to 25 cents a pound.

## FARMERS' BULLETINS.

The bulletins of this series may be obtained by applying to the Secretary of Agriculture, Washington, D. C. The following have been previously issued:

Farmers' Bulletin No. 1. The What and Why of Agricultural Experiment Stations. (A brief explanation of the object, origin, and development of the stations, their work in Europe and in the United States, and the operations of the Office of Experiment Stations of the Department of Agriculture.) Pp. 16. Issued June, 1889.

Farmers' Bulletin No. 2. The Work of the Agricultural Experiment Stations. (Illustrations of station work in the following lines: Better cows for the dairy; fibrin in milk; bacteria in milk, cream, and butter; silos and silage; alfalfa; and field experiments with fertilizers.) Pp. 16. Issued June, 1889.

Farmers' Bulletin No. 3. The Culture of the Sugar Beet. By H. W. Wiley, Chemist of the Department of Agriculture. Pp. 24. Issued March, 1891.

Farmers' Bulletin No. 4. Fungous Diseases of the Grape and their Treatment. By B. T. Galloway, Chief of the Division of Vegetable Pathology. Pp. 12. Issued March, 1891.

Farmers' Bulletin No. 5. Treatment of Smuts of Oats and Wheat. By W. T. Swingle, of the Division of Vegetable Pathology. Pp. 8. Issued February, 1892.

Farmers' Bulletin No. 6. Tobacco: Instructions for its Cultivation and Curing. Prepared by John M. Estes. Pp. 8. Issued February, 1892.

Farmers' Bulletin No. 7. Spraying Fruits for Insect Pests and Fungous Diseases, with a Special Consideration of the Subject in its Relation to the Public Health. Pp. 20. Issued April, 1892.

Farmers' Bulletin No. 8. Results of Experiments with Inoculation for the Prevention of Hog Cholera. By D. E. Salmon, Chief of the Bureau of Animal Industry. Pp. 40. Issued May, 1892.

Farmers' Bulletin No. 9. Milk Fermentations and their Relations to Dairying. Pp. 24. Issued July, 1892.

Farmers' Bulletin No. 10. The Russian Thistle and other Troublesome Weeds in the Wheat Region of Minnesota and North and South Dakota. By L. H. Dewey,

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 19.

# MPORTANT INSECTICIDES:

## DIRECTIONS FOR THEIR PREPARATION AND USE.

[REVISED EDITION.]

BY

C. L. MARLATT,
FIRST ASSISTANT ENTOMOLOGIST.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

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## FARMERS' BULLETINS.

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No. 31. Alfalfa, or Lucern. Pp. 23.
No. 32. Silos and Silage. Pp. 31.
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No. 34. Meats: Composition and Cooking. Pp. 29.
No. 35. Potato Culture. Pp. 24.
No. 36. Cotton Seed and Its Products. Pp. 16.
No. 37. Kafir Corn: Characteristics, Culture, and Uses. Pp. 12.
No. 38. Spraying for Fruit Diseases. Pp. 12.
No. 39. Onion Culture. Pp. 30.

## LETTER OF TRANSMITTAL.

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U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
*Washington, D. C., January 17, 1895.*

SIR: I have the honor to transmit herewith a revised edition of Farmers' Bulletin No. 19, a condensed account of the more important insecticides for farm and garden use, prepared under my direction by Mr. C. L. Marlatt, first assistant entomologist. As stated in my letter of transmittal to the first edition, circular No. 1, new series, of this division, contained information of this character, but this document is out of print, and since it was published some advance has been made in the matter of insecticides which necessitates the publication of some additional matter and some change in the methods of preparation of old and standard mixtures. The constant call for information of this character will warrant the publication of this bulletin in large edition.

Respectfully,

L. O. HOWARD, *Entomologist.*

Hon. CHAS. W. DABNEY, Jr.,
*Acting Secretary of Agriculture.*

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# RTANT INSECTICIDES: DIRECTIONS FOR THEIR PREPARATION AND USE.

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thout going minutely into the field of remedies and preventives sect depredators, it is proposed to give in this bulletin brief direc- concerning a few of the insecticide agents having the widest range ttended with the greatest usefulness, economy, and ease of appli- n. These are not covered by patent, and in general it is true that atented articles are inferior, and many of the better of them are t merely more or less close imitations of the standard substances compounds hereinafter described. Only such brief references to and other habits of the insects covered will be included as are sary to illustrate the principles underlying the use of the several ticide agents recommended.

## RELATION OF FOOD HABITS TO REMEDIES.

the intelligent and practical employment of insecticides it is nec- y to comprehend the nature and method of injury commonly due sects. Omitting for the present purpose the many special cases ury which necessitate peculiar methods of treatment, the great of the harm to growing plants from the attacks of insects falls two principal heads based on distinct principles of food economy ects, viz, whether they are biting (mandibulate) or sucking (haus- e), each group involving a special system of treatment.

### INJURY FROM BITING INSECTS.

biting or gnawing insects are those which actually masticate and ow some portion of the solid substance of the plant, as the wood, leaves, flowers or fruit. They include the majority of the injurious , many beetles, and the locusts.

r these insects direct poisons, such as the arsenicals, which may be applied to the leaves or other parts of the plant attacked, and h will be swallowed by the insect with its food, furnish the surest implest remedy, and should always be employed except where the treated are themselves to be shortly used for the food of other als or of man.

### INJURY FROM SUCKING INSECTS.

The sucking insects are those which injure plants by the gradual extraction of the juices, either from the bark, leaves, or fruit, and include the plant-bugs, plant-lice, scale insects, thrips, and plant-feeding mites. These insects possess, instead of biting jaws, sucking beaks or bristles, which are thrust down through the outer layers of the bark or leaves into the soft, succulent tissues beneath and used to extract the plant juices, with a resulting injury not so noticeable as in the first group, but not less serious.

For this class of insects the application of poisons, which penetrate little, if at all, into the plant cells, is of trifling value, and it is necessary to use substances which will act externally on the bodies of these insects, either as a caustic or to smother or stifle them by closing their breathing pores, or to fill the air about them with poisonous fumes. Of value also as repellants are various deterrent or obnoxious substances.

Wherever it is not desirable to use poisons for biting insects, some of the means just enumerated will often be available.

### GROUPS SUBJECT TO SPECIAL TREATMENT.

The general grouping outlined above relates to the species which live and feed upon the exterior of plants for some portions or all of their lives, and includes the great majority of the injurious species. Certain insects, however, owing to peculiarities of habit, inaccessibility, or other causes, require special methods of treatment. Of these, two groups properly come within the scope of this bulletin: (1) Those working beneath the soil, or subterranean insects, such as the white grubs, root-maggots, root-lice, etc., and (2) insects affecting stored products, as various grain and flour pests.

Three other groups, which include species requiring very diverse methods of treatment, and therefore not coming within the limits of this bulletin, are (1) the internal feeders, such as wood, bark, and stem borers, leaf-miners, gall insects, and species living within fruits; (2) household pests, and (3) animal parasites.

The classification of insects outlined above, based on mode of nourishment and indicating groups amenable to similar remedial treatment, simply stated, is as follows:

I. External feeders:
    (*a*) Biting insects.
    (*b*) Sucking insects.
II. Internal feeders.
III. Subterranean insects.
IV. Insects affecting stored products.
V. Household pests.
VI. Animal parasites.

## INSECTICIDES FOR EXTERNAL BITING INSECTS (FOOD POISONS).

### THE ARSENICALS: PARIS GREEN AND LONDON PURPLE.

The arsenical compounds have supplanted all other substances for the insects falling under this heading. Two compounds are in common use, viz, Paris green and London purple.[1] The use of powdered white arsenic is not recommended, on account of its greater liability to scald foliage and because it is very apt to be mistaken for harmless substances. Of the first two mentioned, Paris green is the stronger insecticide, acting quickly, and is less liable to burn foliage. London purple has the advantage ot cheapness, and, being more finely powdered, is kept more easily suspended in water. The former can be had in 14-pound or larger cans at 20 cents per pound, and the latter at 10 cents per pound by the barrel.

### HOW TO APPLY ARSENICALS.

There are three principal methods of applying arsenicals. The wet method, which consists in using these poisons in water in the form of spray, is the standard means, secures uniform results at least expense, and is the only practical method of protecting fruit and shade trees. The dry application of these poisons in the form of a powder, which is dusted over plants, is more popular as a means against the cotton worm in the South, where the rapidity of treatment possible by this method, and its cheapness, give it a value against this insect, in the practical treatment of which prompt and economical action are the essentials. This method is also feasible for any low-growing crop, such as the potato. The third method consists in the use of the arsenicals in the form of poisoned baits, and is particularly available for such insects as cutworms, wireworms, and local invasions of locusts.

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[1] A third arsenical which promises well, arsenate of lead, has lately been experimented with by the Gypsy Moth Commission. While not urging that this insecticide has advantages over Paris green, it is held that it has the merit of showing on the leaves, indicating at once which have been sprayed, remains much more easily suspended in water, and may be used in large proportions without danger to foliage. It has recently been extensively tested at the Department, and a strength as great as 1 pound to 2 gallons of water has been used on tender foliage of the peach and Osage orange without injury. Good results have attended its use also against the imported elm leaf-beetle. The insecticide results were not better, however, than with Paris green; but for such sensitive foliage as that of the peach, or where no risk of scalding may be taken, I am inclined to believe that it will prove useful.

This insecticide is prepared by combining, approximately, 3 parts of arsenate of soda with 7 parts of acetate of lead. These substances unite chemically and form a fine, white powder which remains easily in suspension. As now used by the Commission, 10 pounds of the arsenate of lead are used with 150 gallons of water, 2 quarts of glucose being added to cause the insecticide to adhere longer to the leaves. Professor Fernald's experience and our own would indicate that from one-fourth to one-half this strength will answer for most larvæ—the larvæ of the gypsy moth proving to be unusually resistant to the action of poisons. The arsenate of lead costs the commission 7 cents a pound wholesale, and glucose $16 a barrel.

*The wet method.*—Either Paris green or London purple may be used at the rate of 1 pound to 100 to 250 gallons of water, or 1 ounce to 6 to 15 gallons. The stronger mixtures are for such vigorous foliage as that of the potato, for the Colorado potato-beetle, and the greater dilutions for the more tender foliage of the peach or plum. An average of 1 pound to 150 gallons of water is a good strength for general purposes. The poison should be first made into a thin paste in a small quantity of water and powdered or quick lime added in amount equal to the poison used to take up the free arsenic and remove or lessen the danger of scalding. An excess of lime will do no injury. The poisons thus mixed should be strained into the spray tank or reservoir, care being taken that all the poison is pulverized and washed through the meshes of the strainer. The use of the lime is especially desirable in the case of the peach and plum, the foliage of which, particularly the former, is very tender and easily scalded. To the stronger foliage of the apple and most shade trees Paris green may be applied at the strength of 1 pound to 150 gallons of water without danger; with London purple it is always better to use the lime.

If it be desirable to apply a fungicide at the same time, as on the apple for the codling moth and the apple scab fungus, the Bordeaux mixture[1] may be used instead of water, adding the arsenical to it at the same rate per gallon as when water is used. The lime in this fungicide neutralizes any excess of free arsenic and makes it an excellent medium for the arsenical, removing, as it does, all liability of scalding the foliage and enabling an application of the arsenical, if necessary, eight or ten times as strong as it could be employed with water alone.

The arsenicals can not be safely used with most other fungicides, such as the sulphate of copper, eau celeste or iron chloride solution, the scalding effects of these in the mixture being greatly intensified.

*The dry method.*—The following description applies to the pole-and-bag duster commonly used against the cotton worm: A pole 5 to 8 feet long and about 2 inches in diameter is taken, and a three-fourths inch hole bored through it within 6 inches of either end. Near each end is securely tacked a bag of "8-ounce osnaburg cloth," 1 foot wide and 18 inches to 2 feet long, so that the powdered poison may be introduced into the bags with a funnel through the holes at the ends of the pole. The bags are filled with undiluted Paris green, which is generally preferred to London purple on account of its quicker action, and the apparatus is carried, on horse or mule back, through the cotton fields, dusting two or four rows at once. The shaking induced by the motion of the animal going at a brisk walk or at a trot is sufficient to dust the plants thoroughly, or the pole may be jarred by hand. The application is preferably made in early morning or late evening when the dew is on, to cause the poison to adhere better to the foliage.

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[1] *Bordeaux mixture formula.*—Into a 50-gallon barrel pour 30 gallons of water, and suspend in it 6 pounds of bluestone in coarse sacking. Slack 4 pounds of fresh lime in another vessel, adding water slowly to obtain a creamy liquid, free from grit. When the bluestone is dissolved add the lime milk slowly with water enough to fill the barrel, stirring constantly.

With insufficient lime the mixture sometimes injures the foliage, and it should be tested with a solution obtained by dissolving an ounce of yellow prussiate of potash (potassium ferrocyanide) in one-half pint of water. If there be insufficient lime in the Bordeaux mixture the addition of a drop or two of this solution will cause a brownish-red color, and more lime should be added until no change takes place when the solution is dropped in. Use the Bordeaux mixture promptly, as it deteriorates on standing.

Stock solutions of both the bluestone and lime may be kept for any length of time. Make the stock bluestone by dissolving in water at the rate of 2 pounds to the gallon. The stock lime is slacked and kept as a thick paste. Cover both mixtures to prevent evaporation and keep the lime moist. For the 50-gallon formula add 3 gallons of the bluestone solution to 50 gallons of water, and introduce the stock lime slowly until there is no reaction with the testing solution.—B. T. G.

From 1 to 2 pounds are required to the acre, and from 10 to 20 acres are covered in a day. The occurrence of heavy rains may necessitate a second application, but frequently one will suffice. This simple apparatus, on account of its effectiveness and cheapness, is employed throughout the cotton belt to the general exclusion of more complicated and expensive machinery.

With the patented air-blast machines for the dry distribution of poisons, arsenicals are diluted with 10 parts of flour, lime, or ground gypsum, and from 60 to 75 acres may be covered in a day by using relays of men and teams. Greater uniformity is secured with these machines in distribution of the poisons, but their cost (from $30 to $60) prevents their general use.

The planter should have a good supply of poison on hand and apparatus for its application prepared in advance, since when the worm puts in an appearance its progress is very rapid, and a delay of a single day may result in material damage to the crop.

If small garden patches are dusted with poison by this or similar means from bags or with hand powder bellows, it is advisable always to dilute the poison with 10 parts of flour, or preferably lime, and for application to vegetables which may soon be used for food, as the cabbage, 1 ounce of the poison should be mixed with 6 pounds of flour or 10 of lime, and dusted merely enough to show evenly over the surface.

*As poisoned bait.*—It is not always advisable or effective to apply arsenicals directly to the plants, and this is particularly true in the case of the attacks of the grasshopper and of the various cutworms and wireworms. In such cases the use of poisoned bait has proven very satisfactory.

For locusts, take 1 part by weight of white arsenic, 1 of sugar, and 6 of bran, to which add water to make a wet mash. Place a teaspoonful of this at the base of each tree or vine, or apply a line of baits just ahead of the advancing army of grasshoppers, placing a tablespoonful of the mash every 6 or 8 feet, and following up with another line behind the first.

For baiting cutworms and wireworms, distribute poisoned gr succulent vegetation, such as freshly cut clover, in small bunches ab in the infested fields. Dip the bait in a very strong arsenical soluti and protect from drying by covering with boards or stones. Re the bait as often as it becomes dry, or every three to five days. bran-arsenic bait will also answer for cutworms.

### TIME TO SPRAY FOR BITING INSECTS.

For the codling moth, the apple and pear should receive the f application very soon after the blossoms fall, which is also the time the second treatment of the scab fungus; the second spraying should given one or two weeks later, just before the fruit turns down on stem or when it is from one-fourth to one-half inch in diameter. first spraying reaches the eggs laid by the moth in the flower en the fruit shortly after the falling of the blossoms, and the second later egg-laying by the more belated moths, when the first coating poison will probably have been washed off by rains. The young lar eating its way from without into the fruit, gets enough of the poison destroy it. This treatment reaches at the same time a large num of leaf-feeding enemies of these fruit trees.

For the Curculio of the stone fruits, plum, cherry, peach, etc., t or three applications should be made; the first before the trees blo or as soon as the foliage is well started, the second at the time of exposure of the young fruit by the falling of the blossoms, and perha a third a week later, particularly if rains have intervened after the l treatment. The poison here acts to destroy the parent Curculio inste of the young larvæ, which, hatching from eggs placed beneath the sk of the fruit, are not affected by the poison on the outside. The ad Curculio, however, as soon as it comes from its hibernation feeds on t foliage before the trees bloom, and later on the young fruit also, and destroyed by the arsenical before its eggs are deposited.

For leaf feeding insects in general, such as the Colorado potato-b tle, blister beetles, elm leaf-beetle, maple worm, etc., the applicati should be made at the earliest indication of injury and repeated often as necessary. Fruit trees should never be sprayed when in blo on account of the liability of poisoning honey bees or other inse useful as cross fertilizers.

### CARE IN USE OF ARSENICALS.

It must be remembered that these arsenicals are very poisonous, a should be so labeled. If ordinary precautions are taken there is danger to man or team attending their application, and the wetting either, which can not always be avoided, is not at all dangerous, account of the great dilution of the mixture, and no ill results wh ever have resulted from this source.

The poison disappears from the plants almost completely with wenty to twenty-five days, and even if the plants were consumed hortly after the application an impossible quantity would have to be aten to get a poisonous dose. To illustrate, in the case of the apple, f the entire fruit were eaten, core and all, it would take several barrels at a single sitting to make a poisonous dose (Riley), and with the cabbage, dusted as recommended above, 28 heads would have to be eaten at one meal to reach this result (Gillette). It is preferable, however, to use other insecticides in the case of vegetables soon to be eaten, and thus avoid all appearance of danger.

## INSECTICIDES FOR EXTERNAL SUCKING INSECTS (CONTACT POISONS).

The simple remedies for this class of insects, such as soap and lye washes, tobacco decoction, etc., are frequently of the greatest service, but need no special explanation. The whale oil is the most valuable of the soaps, and at the rate of 1 pound to 4 gallons of water, dissolved by heating, kills most soft-bodied insects, and at 1 to 2 pounds to the gallon is an effective winter wash for scale insects, even the very resistant San José scale succumbing to the latter strength. The insect powders (Pyrethrum or Buhach) are effective, but too expensive for any but limited or indoor use. The following are standard remedies for this group of insects: Kerosene emulsions, resin washes, hydrocyanic acid gas, and vapor of bisulphide of carbon.

### THE KEROSENE WASHES.

*The kerosene and soap emulsion formula.*

| | | |
|---|---|---|
| Kerosene | gallons | 2 |
| Whale-oil soap (or 1 quart soft soap) | pound | ½ |
| Water | gallon | 1 |

The soap, first finely divided, is dissolved in the water by boiling and immediately added boiling hot, away from the fire, to the kerosene. The whole mixture is then agitated violently while hot by being pumped back upon itself with a force pump and direct-discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. After from three to five minutes' pumping the emulsion should be perfect, and the mixture will have increased from one-third to one-half in bulk and assumed the consistency of cream. Well made, the emulsion will keep indefinitely, and should be diluted only as wanted for use.

The use of whale-oil soap, especially if the emulsion is to be kept for any length of time, is strongly recommended, not only because the soap possesses considerable insecticide value itself, but because the emulsion made with it is more permanent, and does not lose its creamy consistency, and is always easily diluted, whereas with most of the other common soaps the mixture becomes cheesy after a few days and needs reheating to mix with water. Soft [illegible] answers very well, and 1 quart of it may be taken in lieu of the [illegible]

In limestone regions or where the water is very hard some of the soap will combine with the lime or magnesia in the water and more or less of the oil will be freed, especially when the emulsion is diluted. Before using, such water should be broken with lye, or rain water employed; but better than either, follow the milk emulsion formula with which the character of the water, whether hard or soft, does not affect the result.

*The kerosene and milk emulsion formula.*

| | | |
|---|---|---|
| Kerosene | gallons | 2 |
| Milk (sour) | gallon | 1 |

Heating is unnecessary in making the milk emulsion, which otherwise is churned, as in the former case. The change from a watery liquid to a thick buttery consistency, much thicker than with the soap, takes place very suddenly after three to five minutes' agitation. With sweet milk difficulty will frequently be experienced, and if the emulsion does not result in five minutes, the addition of a little vinegar will induce prompt action. It is better to prepare the milk emulsion from time to time for immediate use, unless it can be stored in quantity in air-tight jars, otherwise it will ferment and spoil after a week or two.

*How to use the emulsions.*—During the growing period of summer, for most plant-lice and other soft-bodied insects, dilute the emulsion with from 15 to 20 parts of water; for the red spider and other plant mites the same, with the addition of 1 ounce of powdered sulphur to the gallon; for scale insects, the larger plant bugs, larvæ, and beetles, dilute with from 7 to 9 parts water; apply with spray pump.

For winter applications to the trunks and larger limbs of trees, in the dormant and leafless condition, to destroy scale insects, stronger mixtures may be used even to the pure emulsion, which latter can not be sprayed successfully but may be applied with brush or sponge. Diluted with one or more parts of water it may be applied in spray without difficulty. The use of the pure emulsion is heroic treatment and only advisable in cases of excessive infestation, and in general it is much better and safer to defer the treatment until the young scales hatch in the spring, when the nine-times diluted wash may be used with more certain results and without danger to plants. The winter treatment should be followed by a use of the spring wash to destroy any young which may come from female scales escaping the stronger mixture.

*Pure kerosene.*—The pure oil may be applied as a winter wash to the older parts of plants either in a spray or with a sponge, using the least possible quantity. Its use is not advised save in exceptionally bad cases of infestation and during the dormant period, and should never be attempted after the first sign of spring growth appears.

In many cases plant-bugs and beetles may be jarred into cloths saturated with kerosene or into pans with water and oil and destroyed, where it would be unsafe or inadvisable to spray the plants themselves.

As a remedy against the mosquito, kerosene has proven very effective loward). It is employed to destroy the larvæ of the mosquitoes in eir favorite breeding places in small pools, still ponds, or stagnant ater, and where such bodies of water are not sources of drinking sup-ly or of value for their fish, especially in the case of temporary pools om rains, which frequently breed very disagreeable local swarms, the se of oil is strongly recommended. The kerosene is applied at the ate of 1 ounce to 15 square feet of water surface, and forms a uniform ilm over the surface and destroys all forms of aquatic insect life, ncluding the larvæ of the mosquito and also the adult females coming to the water to deposit their eggs. The application retains its efficiency for several weeks, even with the occurrence of heavy rains.

### THE RESIN WASH.

This wash has proved of greatest value in California, particularly against red scale (*Aspidiotus aurantii*), and will be of use in all similar climates where the occurrence of comparatively rainless seasons insures the continuance of the wash on the trees for a considerable period, and where, owing to the warmth, the multiplication of the scale insects continues almost without interruption throughout the year. Where rains are liable to occur at short intervals, and in the Northern States, the quicker-acting and stronger kerosene washes are preferable. The resin wash acts by contact, having a certain caustic effect, but principally by forming an impervious, smothering coating over the scale insects. The application may be more liberal than with the kerosene washes, the object being to thoroughly wet the bark.

The wash may be made as follows:

| | | |
|---|---|---|
| Resin | pounds | 20 |
| Crude caustic soda (78 per cent) | do | 5 |
| Fish oil | pints | 2¼ |
| Water to make | gallons | 100 |

Ordinary commercial resin is used, and the caustic soda is that put up for soap establishments in large 200-pound drums. Smaller quantities may be obtained at soap factories, or the granulated caustic soda (98 per cent) used—3½ pounds of the latter being the equivalent of 5 pounds of the former. Place these substances with the oil in a kettle with water to cover them to a depth of 3 or 4 inches. Boil for one or two hours, making occasional additions of water, or until the compound resembles very strong black coffee. Dilute to one-third the final bulk with hot water, or with cold water added slowly over the fire, making a stock mixture, to be diluted to the full amount as used. When sprayed the mixture should be perfectly fluid, without sediment, and should any appear in the stock mixture reheating should be resorted to.

As a winter wash for scale insects, and particularly for the more resistant San José scale (*Aspidiotus perniciosus*), stronger washes are necessary. In southern California, for this latter insect, the equivalent of a dilution one-third less, or to 66⅔ gallons instead of 100, has given

very good satisfaction. In Maryland, with this insect, it has p
necessary to use the wash at 6 times the summer strength to destr
of the well-protected hibernating scales; and with other scale i
much stronger mixtures than those used in California have, in th
proved ineffectual. For regions, therefore, with moderately sever
ters, the use of the resin wash to destroy hibernating scale insects
inadvisable.

### TIME TO SPRAY FOR SUCKING INSECTS.

For the larger plant bugs and the aphides, or active plant lic
all other sucking insects which are present on the plants injuriou
comparatively brief periods, or at most during summer only, the
ment should be immediate, and if in the form of spray on the pla
a strength which will not injure growing vegetation.

For scale insects and some others, as the pear Psylla, which
nate on the plants, two or more strengths are advised with most
liquid insecticides recommended, the weaker for summer applic
and the more concentrated as winter washes. The summer wash
scale insects are most effective against the young, and trea
should begin with the first appearance of the larvæ of the spr
any of the later broods, and should be followed at intervals of
days with two or three additional applications. The first broo
the majority of species in temperate regions, will appear durin
first three weeks in May. Examination from time to time with a
lens will enable one to determine when the young of any brood a

The winter washes may be used whenever summer treatment ca
be successfully carried out, and are particularly advantageous i
case of deciduous plants with dense foliage which renders a thor
wetting difficult in summer, or with scale insects which are so irre
in the time of disclosing their young that many summer treat
would be necessary to secure anywhere near complete extermin
In the winter also, with deciduous trees, very much less liqu
required, and the spraying may be much more expeditiously and
oughly done. In the case of badly infested trees, a vigorous pr
is advisable as a preliminary to treatment.

All of the washes mentioned are excellent as summer remedies.
winter washes for temperate regions the kerosene mixtures and w
oil soap solutions, particularly the latter, have so far given the
results. These stronger mixtures may be applied at any time d
the dormant period of vegetation, and, with deciduous trees, prefe
immediately after the falling of the foliage. In the growing seaso
of these stronger washes would cause the loss of foliage and frui
the more concentrated probably the death of the plant.

### THE GAS TREATMENT.

#### *Hydrocyanic Acid Gas.*

The hydrocyanic acid gas treatment of scale-infested trees,
recently exclusively confined to California, has, within the last
been introduced in the East by the Department to combat the Sa

e. Briefly, it consists in inclosing a tree (or nursery stock in greater ess quantities at once) with a tent and filling the latter with the onous fumes generated with potassium cyanide and sulphuric acid.

*he outfit.*—The tents are made of blue or brown drilling or 8-ounce k, and painted or oiled with linseed oil to make them as near air- t as possible. A very convenient form of tent is made in the shape large hexagonal sheet, which, thrown over a tree, will touch the und on all sides. These sheets or tents are placed over the trees by d or with poles in case of small trees, but with trees over 10 feet h some sort of a tripod or derrick is used. The outfit for medium- ed trees—tent and derrick—will cost from $15 to $25. A tent for es 26 feet tall by 60 feet in circumference costs as much as $60.

*The chemicals.*—Commercial fused potassium cyanide, 58 per cent rity (costing in bulk 40 cents per pound), commercial sulphuric acid t 3½ cents per pound), and water are used in generating the gas, the roportions being 1 ounce by weight of the cyanide, slightly more han 1 fluid ounce of the acid, and 3 fluid ounces of water to every 150 ubic feet of space inclosed.

*The method.*—The generator, which may be any glazed earthenware vessel of 1 or 2 gallons' capacity, is placed within the tent under the tree and the water, acid and cyanide, the latter broken up, put in in the order named, after which the operator withdraws from the tent. The tent is allowed to remain on the tree for one-half hour for large trees or fifteen minutes for small ones. The treatment is best made on cloudy days, early in the morning, late in the evening, or at night. Bright, hot sunlight is liable to cause injury to the foliage, which, however, may be largely avoided by using tents of dark material or painted black.

Three or four men can operate six tents at once, and the expense under such conditions, not counting the cost of the outfit, need not be more than 10 cents per tree. One outfit of tents and hoisting apparatus will answer for an entire community or county.

### *Bisulphide of Carbon Vapor.*

In line with the use of hydrocyanic acid gas is the employment of the vapor of bisulphide of carbon to destroy insects on low-growing plants, such as the lice on melon and squash vines. The treatment, as successfully practiced by Professors Garman and Smith, consists in covering the young vines with small tight boxes 12 to 18 inches in diameter, of either wood or paper, and introducing under each box a saucer containing one or two teaspoonfuls (1 or 2 drams) of the very volatile liquid, bisulphide of carbon. The vines of older plants may be wrapped about the hill and gathered in under larger boxes or tubs, and a greater, but proportional, amount of bisulphide used. The covering should be left over the plants for three quarters of an hour to an hour, and with 50 to 100 boxes a field may be treated with comparative rapidity.

## DUSTING AND SPRAYING APPARATUS.

For the application of powders the dusting bags already described are very satisfactory, or for garden work some of the small powder bellows and blowers are excellent. The best of these cost about $2 each and are on the market in many styles.

Better apparatus is required for the wet applications where successful results require the breaking up of the liquid into a fine mist-like spray. The essential features of such an apparatus are a force pump, several yards of one-half inch cloth-reinforced hose with bamboo hoisting rod, and a spray tip. The size of the apparatus will depend on the amount of vegetation to be treated. For limited garden work and for the treatment of low plants the knapsack pumps or the small bucket force-pumps are suitable, the former costing about $14 and the latter from $6 to $9.

Ready fitted pumps, knapsack and others, for the application of insecticides, are now made by all the leading pump manufacturers of this country and also large reservoirs with pump attached for extended orchard operations, the price of the latter ranging from $25 to $75.

The cost of a spraying outfit for orchard work may be greatly reduced by combining a suitable pump and fixtures with a home-constructed tank or barrel to be mounted on a cart or wagon. A spray-tank having a capacity of about 150 gallons is a very satisfactory size, and may be conveniently made 4 feet long, by 2½ wide by 2 deep, inside measurements. It should be carefully constructed, so as to be water-tight, and should be strengthened by four iron bolts or rods across the ends, one each at the top and bottom. A good double-acting force-pump may be obtained from any of the leading pump manufacturers at a cost of from $10 to $20, depending upon whether of iron or brass, and the nature of its fittings. For use in a very large orchard or in city parks, it may be advisable to construct the tank of twice the capacity mentioned to expedite the spraying and to avoid the more frequent refillings necessary with the smaller tank.

The more economical spray tips in the amount of liquid required are the different styles of cyclone nozzles, the best form of which is known to the market generally as the Vermorel nozzle. These are manufactured by the leading spray pump companies. Other good nozzles are also on the market. The common garden spraying and hose nozzles are much too coarse for satisfactory work, and are wasteful of the liquid.

A prime essential in spraying, especially where the large reservoirs are employed, is to keep the liquid constantly agitated to prevent the settling of the poison to the bottom of the tank. This may be accomplished by constant stirring with a paddle, by shaking, but preferably by throwing a stream of the liquid back into the tank. Many of the larger pumps are now constructed with two discharge orifices with the latter object in view, and the use of such is recommended.

For fruit trees of average size, or, if apple, such as would produce from 10 to 15 bushels of fruit, from 3 to 7 gallons of spray are necessary to thoroughly wet each tree. For smaller trees, such as plum and cherry, 1 gallon to the tree will be sufficient. If an average of 5 gallons to the tree be taken for an apple orchard of 1,000 trees 5,000 gallons of spray would be required. About 33 pounds of paris green or london purple would be needed for one spraying, if used at the rate of 1 pound to 150 gallons of water, and for the two applications ordinarily recommended, 66 pounds. This, for the paris green, at 20 cents a pound, would amount to $13.20, and the london purple, at 10 cents a pound, to $6.60, or a little over 1 cent a tree for the former and one-half a cent for the latter.

In spraying orchard trees, it will be found convenient in going between the rows to spray on either side, half of each tree in the row at a time and finish on the return, rather than attempt to spray all sides of one tree before taking up another.

The object in spraying is to coat every leaf and part of the plant as ightly as feasible with thoroughness, and to avoid waste in doing this a mist spray is essential. The application to any part should stop when water begins to drip from the leaves. A light rain will not remove the poison, but a dashing one will probably necessitate a renewal of the application.

### REMEDIES FOR SUBTERRANEAN INSECTS.

Almost entire dependence is placed on the caustic washes, or those that act externally, for insects living beneath the soil on the roots of plants, including both sucking and biting insects, prominent among which are the white grubs, maggots in roots of cabbage, radishes, onions, etc., cutworms, wireworms, apple and peach root-lice, the grape phylloxera, and many others.

The insecticide must be one that will go into solution and be carried down by water. Of this sort are the kerosene emulsions and resin wash—the former preferable—the potash fertilizers, muriate and kainit, and bisulphide of carbon. Submersion, wherever the practice of irrigation or the natural conditions make it feasible, has also proven of the greatest service against the phylloxera.

*Kerosene emulsion and resin wash.*—Either the kerosene and soap emulsion or the resin wash, the former diluted 15 times and the latter at the strength of the winter mixture, are used to saturate the soil about the affected plants and either left to be carried down by the action of rains or washed down to greater depths by subsequent waterings.

For the grape phylloxera or the root-louse of the peach or apple, make excavations 2 or 3 feet in diameter and 6 inches deep about the base of the plant, and pour in 5 gallons of the wash. If not a rainy season, a few hours later wash down with 5 gallons of water and repeat with a like amount the day following. It is better, however, to make this treatment in the spring, when the more frequent rains will take the place of the waterings.

For root maggots enough of the wash is put along at the base of the plant to wet the soil to a depth of 1 to 2 inches, preferably following after an hour with a like amount of water.

For white grubs in strawberry beds or in lawns the surface should be wetted with kerosene emulsion to a depth of 2 or 3 inches, following with copious waterings to be repeated for two or three days. The larvæ go to deeper and deeper levels and eventually die.

*Potash fertilizers.*—For white grubs, wireworms, cutworms, corn root-worms, and like insects, on the authority of Prof. J. B. Smith, either the kainit or muriate of potash, the former better, are broadcasted in fertilizing quantities, preferable before or during a rain so that the material is dissolved and carried into the soil at once. These not only act to destroy the larvæ in the soil, but are deterrents, and truck lands constantly fertilized by these substances are noticeably free from attacks of insects. This, in a measure, results from the increased vigor and greater resistant power of the plant, which, of itself, more than compensates for the cost of the treatment. The value of these fertilizers against the wireworms is, however, questioned by Prof. J. H. Comstock.

For the root-louse of peach and apple work the fertilizer into the general surface of the soil about the trees, or put it in a trench about the tree 2 feet distant from the trunk.

For cabbage and onion maggots apply in little trenches along the roots at the rate of 300 to 500 pounds to the acre, and cover with soil.

These fertilizers (and the nitrate of soda is nearly as good) are also destructive to the various insects which enter the soil for hibernation or to undergo transformation.

*Bisulphide of carbon.*—This is the great French remedy for the phylloxera, 150,000 acres being now subjected to treatment with it, and applies equally well to all other root-inhabiting lice. The treatment is made at any season except the period of ripening of the fruit, and consists in making holes about the vines 1 foot to 16 inches deep and pouring into each about one-half ounce of bisulphide, and closing the hole with the foot. These injections are made about 1½ feet apart, and not closer to the vines than 1 foot. It is better to make a large number of small doses than a few large ones. Hand injectors and injecting plows are employed in France to put the bisulphide into the soil about the vines, but a short stick or iron bar may be made to take the place of these injectors for limited tracts.

For root maggots a teaspoonful is poured into a hole at the base of the plant, covering as above.

For ant nests an ounce of the substance is poured into each of several holes made in the space occupied by the ants, the openings being then closed, or the action is made more rapid by covering with a wet blanket for ten minutes and then exploding the vapor at the mouth of the holes with a torch, the explosion driving the fumes more thoroughly through the soil.

*Submersion.*—This very successful means against the phylloxera is now practiced over some 75,000 acres of vineyards in France which were once destroyed by the grape root-louse, and the production and quality of fruit has been fully restored. In this country it will be particularly available in California and in all arid districts where irrigation is practiced, otherwise it will be too expensive to be profitable. The best results are secured in soils in which the water will penetrate rather slowly, or from 6 to 18 inches in twenty-four hours; in loose, sandy soils it is impracticable on account of the great amount of water required. Submersion consists in keeping the soil of the vineyard flooded for from eight to twenty days after the fruit has been gathered and active growth of the vine ceased, or during September or October, but while the phylloxera is still in active development. Early in September eight to ten days will suffice; in October, fifteen to twenty days, and during the winter, as was formerly practiced, forty to sixty days. Supplementing the short fall submergence a liberal July irrigation, amounting to a forty-eight-hour flooding, is customary to reach any individuals surviving the fall treatment, and which in midsummer are very susceptible to the action of water.

To facilitate the operation vineyards are commonly divided by embankments of earth into square or rectangular plots, the former for level and the latter for sloping ground, the retaining walls being protected by coverings of reed grass, etc., during the first year, or until they may be seeded to some forage plant.

This treatment will destroy many other root-attacking insects or those hibernating beneath the soil, and, in fact, is a very ancient practice in certain oriental countries bordering the Black Sea and the Grecian Archipelago.

## REMEDIES FOR INSECTS AFFECTING GRAIN AND OTHER STORED PRODUCTS.

The chief loss in this direction from insects is to grains in farmers' bins, or grain or grain products in stores, mills, and elevators, although in the warmer latitudes much of the injury results from infestation in the field between the ripening of the grain and its storage in bins or granaries. Fortunately, the several important grain insects are amenable to like treatment. Aside from various important preventive considerations, such as, in the South, prompt threshing of grain after harvesting, the thorough cleansing of bins before refilling, constant sweeping, removal of waste harboring insects from all parts of granaries and mills, and care to prevent the introduction of "weeviled" grain, there are three valuable remedial measures, viz, agitation of the grain, heating, and dosing with bisulphide of carbon.

The value of agitating or handling grain is well known, and whenever, as in elevators, grain can be transferred or poured from one bin into another grain pests are not likely to trouble. The benefit will depend upon the frequency and thoroughness of the agitation, and in France machines for shaking the grain violently have been used with success. Winnowing weeviled grain is also an excellent preliminary treatment.

Raising the temperature of the grain in closed retorts or revolving cylinders to 130° to 150° F. will kill the inclosed insects if continued for from three to five hours, but is apt to injure the germ, and is not advised in case of seed stock. The simplest, cheapest, and most effectual remedy is the use of bisulphide of carbon.

## BISULPHIDE OF CARBON.

This is a colorless liquid with very offensive odor, which, however, passes off completely in a short time. It readily volatilizes and the vapor, which is very deadly to insect life, is heavier than air and settles and fills any compartment or bin in the top of which the liquid is placed. It may be distributed in shallow dishes or tins or in saturated waste on the top of grain in bins, and the gas will settle and permeate throughout the mass of the grain. In large bins, to hasten and equalize the operation, it is well to put a quantity of the bisulphide in the center of the grain by thrusting in balls of cotton or waste tied to a stick and saturated with the liquid, or by means of a gas pipe loosely plugged at one end, down which the liquid may be poured and the plug then loosened with a rod. In moderately tight bins no further precaution than to close them well need be taken, but in open bins it will be necessary to cover them over with a blanket to prevent the too rapid dissipation of the vapor. The bins or buildings should be kept closed from 24 to 36 hours, after which a thorough airing should be given them.

Limited quantities at a time may often be advantageously subjected to treatment in small bins before being placed for long storage in large masses, and especially whenever there is danger of introducing infested grain.

The bisulphide is applied at the rate of 1 pound to the ton of grain or a pound to a cubic space 10 feet on a side.

In the case of mills, elevators, or larger granaries the application may be best made on Saturday night, leaving the building closed over Sunday, with a watchman without to see that no one enters and to guard against fire. The bisulphide should be first distributed in the lower story, working upward to avoid the settling vapor, using the substance very freely, in waste or dishes, at all points of infestation and over bins throughout the building.

This insecticide may also be used in other stored products, as pease, beans, etc., and very satisfactorily where the infested material can be inclosed in a tight can, chest or closet for treatment.

The bisulphide costs, in 50-pound cans, 10 cents per pound, and in small quantities, of druggists, 25 to 35 cents per pound.

*Caution.*—The bisulphide may be more freely employed with milling grain than that intended for seeding, since used excessively it is liable to injure the germ. It must always be remembered that the vapor is highly inflammable and explosive, and that no fire or lighted cigars, etc., should be in the building during its use. If obtained in large quantities it should be kept in tightly closed vessels and away from fire, preferably in a small outbuilding.

### CONTROL OF INSECTS BY CULTURAL METHODS.

It is much easier to ward off an attack of insects or to make conditions unfavorable for their multiplication than to destroy them after they are once in possession; and in controlling them, methods and systems of farm and orchard culture have long been recognized as of the greatest value—more so even than the employment of insecticides, which, in most cases, can only stop an injury already begun. Insects thrive on neglect, multiply best in land seldom or never cultivated, and winter over in rubbish, prunings, or the undisturbed soil about their food plants, and become, under these conditions, more numerous every year. It is a fact of common observation that it is the neglected farm, vineyard, or orchard filled with weeds or wild growth which is certain to be stocked with all the principal insect enemies; and, on the other hand, thorough and constant culture, with the removal and burning of prunings, stubble, and other waste, the collection and destruction of fallen and diseased fruit, and the practice, where possible, of fall plowing to disturb the hibernating quarters of field insects, will almost certainly be accompanied by comparative immunity from insect pests.

The vigor and healthfulness of plant growth has also much to do with freedom from insect injury, such plants seeming to have a native power of resistance which renders them, in a measure, distasteful to most insects, or at least able to throw off or withstand their attacks. A plant already weakened, however, or of lessened vitality from any cause, seems to be especially sought after, is almost sure to be the first affected,and furnishes a starting point for general infestation. Anything, therefore, which aids good culture in keeping plants strong and vigorous, such as the judicious use of fertilizers, will materially assist in preventing injury.

To the constant cropping of large areas of land year after year to the same staple is largely due the excessive loss from insects in this country as compared with European countries, because this practice furnishes the best possible conditions for the multiplication of the

the other two-thirds was estimated at $2,500. The saving to the plum crop and other small fruits frequently amounts to the securing of a perfect crop where otherwise no yield whatever of sound fruit could be secured.

An illustration, in the case of field insects, may also be given where, by the adoption of a system of rotation, in which oats were made to alternate with corn, the owner of a large farm in Indiana made a saving of $10,000 per year, this amount representing the loss previously sustained annually from the corn root-worm. The cotton crop, which formerly in years of bad infestation by the leaf-worm was estimated to be injured to the extent of $30,000,000, is now comparatively free from such injury, owing to the general use of arsenicals.

Facts of like import could be adduced in regard to many other leading staples, but the foregoing are sufficient to emphasize the money value of intelligent action against insect enemies, which, with the present competition and diminishing prices, may represent the difference between a profit or a loss in agricultural operations.

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U. S. DEPARTMENT OF AGRICULTURE.

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FARMERS' BULLETIN No. 22.

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# THE FEEDING OF FARM ANIMALS.

[REVISED EDITION.]

BY

E. W. ALLEN, Ph. D.,
Assistant Director of the Office of Experiment Stations.

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# LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
*Washington, D. C., October 19, 1901.*

Sir: I have the honor to transmit herewith revised copy for Farmers' Bulletin No. 22, on The Feeding of Farm Animals, prepared under my direction by E. W. Allen, Ph. D., assistant director of this Office. In this article the attempt has been made to make a clear and concise explanation of the principles on which the successful feeding of farm animals is based. These principles have been established by feeding experiments and other investigations at experiment stations and similar institutions in Europe and America, combined with observations of the practice of successful feeders. The present bulletin has been confined to a statement of the general principles of feeding with the expectation that hereafter it may be possible to discuss the application of these principles to different kinds of farm animals in other publications of this series.

In this second revision of the bulletin certain changes have been made on the basis of more recent information.

Respectfully,

A. C. True,
*Director.*

Hon. James Wilson,
*Secretary of Agriculture.*

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# THE FEEDING OF FARM ANIMALS.

## PRINCIPLES OF FEEDING.

The feeding of farm animals, like the use of fertilizers for crops, rests upon quite well-defined general principles. Our knowledge of these principles has been derived from the studies of the chemist and the animal physiologist, on the composition and functions of food and the way it is utilized after it is eaten. These studies have shown that the materials of the body are continually breaking down and being consumed, and that to keep the animal in a healthy and vigorous condition there must be a constant supply of new material. If this is lacking, or is insufficient, hunger and finally death result. To keep up this supply is one of the chief functions of food, but in addition to this the food maintains the heat of the body and at the same time furnishes the force or energy which enables the animal to move the muscles and do work, and also to perform the necessary functions of the body. In furnishing heat and energy the food may be said to serve as fuel. If, in addition to repairing the wastes of the system and furnishing it with heat and energy, growth is to be made (as in the case of immature animals) or milk secreted, an additional supply of food is required. To supply food in the right proportion to meet the various requirements of the animal, without a waste of food nutrients, constitutes scientific feeding. It is by carefully studying the composition of feeding stuffs, the proportion in which they are digested by different animals and under different conditions, and the requirement of animals for the various food nutrients when at rest, at work, giving milk, producing wool, mutton, beef, pork, etc., that the principles of feeding have been worked out. In applying these principles in practice the cost and special adaptations of different feeding stuffs must of course be taken into account.

## COMPOSITION OF THE ANIMAL BODY.

The animal body is made up mainly of four classes of substances—water, ash or mineral ingredients, fat, and nitrogenous matters. The proportion in which these four classes of substances occur depends upon the age of the animal, treatment, purpose for which it is kept, etc.

Water constitutes from 40 to 60 per cent of the body, and is an essential part. From 2 to 5 per cent of the weight of the body is ash. This occurs mainly in the bones. The fat varies greatly with the condition of the animal, but seldom falls below 6 per cent or rises above 30 per cent. The nitrogenous material or protein includes all of the mate-rials containing nitrogen; all those outside this group are nitroge free, or nonnitrogenous. The nitrogen referred to here is the sam as that mentioned in connection with fertilizers, and is the elemen which constitutes about four-fifths of the atmosphere. It occurs i plants and animals in various compounds grouped under the genera name of protein. Lean meat, white of the egg, and casein of mil (curd) are familiar forms of protein. The flesh, skin, bones, muscles internal organs, brain, and nerves—in short, all of the workin machinery of the body—are composed very largely of protein. Th albuminoids are a class of compounds included under protein.

## COMPOSITION OF FEEDING STUFFS.

The food of herbivorous animals contains the same four groups o substances found in the body, viz, water, ash, protein (nitrogenou materials), and fat; and in addition to these a class of materials calle carbohydrates, defined below.

**Water.**—However dry a feeding stuff may appear to be—whethe hay, coarse fodder, grain, or meal—it always contains a considerab amount of water which can be driven out by heat. The amount ma be only from 8 to 15 pounds per 100 pounds of material, as in ha straw, or grain, but in green corn fodder and silage it amounts nearly 80 pounds, and in some roots to 90 pounds. This wate although it may add to the palatability of a food, is of no more bene to the animal than water which it drinks. For this reason, and becau the proportion of water varies widely, comparisons of different kin of foods are usually made on a dry or water-free basis, which show the percentage of food ingredients in the dry matter.

**Ash** is what is left when the combustible part of a feeding stuff i burned away. It consists chiefly of lime, magnesia, potash, soda iron, chlorin, and carbonic, sulphuric, and phosphoric acids, and used largely in making bones. From the ash constituents of the foo the digestive organs of the animal select those which the animal nee and the rest is voided in the manure. As a general rule rations com posed of a variety of nutritious foods contain sufficient ash to suppl the requirements of the body. Corn, however, is poor in ash, an when fed extensively to growing animals, like pigs, it may be nece sary to add to it some ash material, as wood ashes, charcoal, or bon meal.

**Fat**, or the material which in analysis is dissolved from a feedi stuff by ether, includes, besides real fats, wax, the green colori matter of plants, etc. For this reason the ether extract is usual designated *crude* fat. The fat of food is either stored up in the bo as fat or burned to furnish heat and energy.

**Carbohydrates** are usually divided into two groups: (1) Nitrogen-free extract, including starch, sugar, gums, and the like; and (2) cellulose or fiber, the essential constituent of the walls of vegetable cells. Cotton fiber and wood pulp are nearly pure cellulose. Coarse fodders, like hay and straw, contain a large proportion of fiber, while most grains contain little fiber, but are rich in starch, sugar, etc. (nitrogen-free extract). The carbohydrates form the largest part of all vegetable foods. They are not permanently stored up as such in the animal body, but are either stored up as fat or burned in the system to produce heat and energy. They are one of the principal sources of animal fat.

**Protein** (or nitrogenous materials) is the name of a group of materials containing nitrogen. All other constituents of the feeding stuffs—the ash, fat, and carbohydrates—are nonnitrogenous or free from nitrogen. Protein materials are often designated as "flesh formers," because they furnish the materials for the lean flesh; but they also enter largely into the composition of blood, skin, muscles, tendons, nerves, hair, horns, wool, the casein and albumen of milk, etc. For the formation of these materials protein is absolutely indispensable. No substances free from nitrogen can be worked over into protein or fill the place of protein. It is, then, absolutely necessary for an animal to be provided with a certain amount of protein in order to grow or maintain existence. Under certain conditions it is believed protein may be a source of fat in the body; and finally it may be burned, like the carbohydrates and fat, yielding heat and energy.

## SOURCES OF HEAT AND ENERGY.

The sources of heat and energy in the animal, then, are the protein, fat, and carbohydrates of the food, and the fat and protein of the body, for the fat and protein of the body may be burned like that in the food. The value of the fat for producing heat is nearly two and a half times that of carbohydrates or protein. The sources of fat in the body are the fat, carbohydrates, and, probably, the protein of the food; and the exclusive source of protein in the body is the protein in the food. These groups of food materials are termed nutrients.

## SOURCES OF FAT.

To a certain extent at least the nutrients may replace one another, although, as stated above, no other nutrient can take the place of protein for building tissue and repairing waste of nitrogenous materials in the body. The fat and carbohydrates perform similar functions, and to a large extent carbohydrate materials may replace fat in the food, even when a large fat production is demanded of the animal, as in the case of the cow. For example, Jordan, at the New York State experiment station, fed a cow for ninety-five days upon food from form of chyle passes into the blood and finally serves to nourish and sustain the body. This portion is said to be digested and assimilated, and from it alone the animal is nourished. The other portion, the part not digested, passes on through the body and is excreted as manure.

## PERCENTAGE OF NUTRIENTS DIGESTED.

As the rates of digestibility are not constant for different foods, and as only the digestible portion is of any nutritive use to the animal, it is essential to know in the case of each feeding stuff what part of its protein, fat, and carbohydrates (the total quantity of which is shown by analysis) is actually digested by the animal. This is determined by digestion experiments with animals, and to secure approximately accurate figures the trials are repeated with a large number of animals and under various conditions. The figures obtained represent the percentages of the nutrients digested and are called digestion coefficients.

In the case of clover hay, for instance, on an average 60 per cent of the protein which it contains, 55 per cent of the fat, 55 per cent of the fiber, and 65 per cent of the nitrogen-free extract are digested by cows. The table of composition shows red-clover hay to average 12.3 per cent of protein, or 12.3 pounds of protein in 100 pounds of hay. As only 60 per cent of this is digestible, 100 pounds of hay would contain only 7.38 pounds of digestible protein. The remaining 4.92 pounds of protein are voided and do not aid in nourishing the animal. The amounts of digestible fat and carbohydrates (fiber and nitrogen-free extract) are calculated in a similar way. The digestibility of such coarse fodders as straw, coarse hay, etc., is relatively low. The digestibility, like the composition, varies somewhat for the same kind of feeding stuff grown under different conditions and fed to different animals.

## AMOUNTS OF DIGESTIBLE NUTRIENTS IN DIFFERENT FEEDING STUFFS.

To simplify matters for the feeder, calculations have been made of the amounts of digestible protein, fat, and carbohydrates contained in 100 pounds each of a large number of more commonly used feeding stuffs. As has been fully explained above, they are derived from averages of composition and of digestibility, both of which are subject to considerable variation. In calculating them American analyses and digestion coefficients found in American experiments were used as far as possible. They are the figures which the farmer has to consult to find the approximate food value of a material in selecting his feeding stuffs or making up a ration.

*Dry matter and digestible food ingredients in 100 pounds of feeding stuffs.*

| Feeding stuff. | Total dry matter. | Protein. | Carbohydrates. | Fat. |
|---|---|---|---|---|
| Green fodder: | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Corn fodder[1] (average of all varieties) | 20.7 | 1.10 | 12.08 | 0.37 |
| Kafir-corn fodder | 27.0 | 0.87 | 13.80 | 0.43 |
| Rye fodder | 23.4 | 2.05 | 14.11 | 0.44 |
| Oat fodder | 37,8 | 2.44 | 17.99 | 0.97 |
| Redtop, in bloom | 34.7 | 2.06 | 21.24 | 0.58 |
| Orchard grass, in bloom | 27.0 | 1.91 | 15.91 | 0.58 |
| Meadow fescue, in bloom | 30.1 | 1.49 | 16.78 | 0.42 |
| Timothy,[2] at different stages | 38.4 | 2.01 | 21.22 | 0.64 |
| Kentucky blue grass | 34.9 | 2.66 | 17.78 | 0.69 |
| Hungarian grass | 28.9 | 1.92 | 15.63 | 0.36 |
| Red clover, at different stages | 29.2 | 3.07 | 14.82 | 0.69 |
| Crimson clover | 19.3 | 2.16 | 9.81 | 0.44 |
| Alfalfa,[3] at different stages | 28.2 | 3.89 | 11.20 | 0.41 |
| Cowpea | 16.4 | 1.68 | 8.08 | 0.25 |
| Soy bean | 28.5 | 2.79 | 11.82 | 0.63 |
| Rape | 14.3 | 2.16 | 8.65 | 0.32 |
| Corn silage (recent analyses) | 25.6 | 1.21 | 14.56 | 0.88 |
| Corn fodder,[1] field cured | 57.8 | 2.34 | 32.34 | 1.15 |
| Corn stover, field cured | 59.5 | 1.98 | 33.16 | 0.57 |
| Kafir-corn stover, field cured | 80.8 | 1.82 | 41.42 | 0.98 |
| Hay from— | | | | |
| Barley | 89.4 | 5.11 | 35.94 | 1.55 |
| Oats | 84.0 | 4.07 | 33.35 | 1.67 |
| Orchard grass | 90.1 | 4.78 | 41.99 | 1.40 |
| Redtop | 91.1 | 4.82 | 46.83 | 0.95 |
| Timothy[2] (all analyses) | 86.8 | 2.89 | 43.72 | 1.43 |
| Kentucky blue grass | 78.8 | 4.76 | 37.46 | 1.99 |
| Hungarian grass | 92.3 | 4.50 | 51.67 | 1.34 |
| Meadow fescue | 80.0 | 4.20 | 43.34 | 1.73 |
| Mixed grasses | 87.1 | 4.22 | 43.26 | 1.33 |
| Rowen (mixed) | 83.4 | 7.19 | 41.20 | 1.43 |
| Mixed grasses and clover | 87.1 | 6.16 | 42.71 | 1.46 |
| Red clover | 84.7 | 7.38 | 38.15 | 1.81 |
| Alsike clover | 90.3 | 8.15 | 41.70 | 1.36 |
| White clover | 90.3 | 11.46 | 41.82 | 1.48 |
| Crimson clover | 91.4 | 10.49 | 38.13 | 1.29 |
| Alfalfa[3] | 91.6 | 10.58 | 37.33 | 1.38 |
| Cowpea | 89.3 | 10.79 | 38.40 | 1.51 |
| Soy bean | 88.7 | 10.78 | 38.72 | 1.54 |
| Wheat straw | 90.4 | 0.37 | 36.30 | 0.40 |
| Rye straw | 92.9 | 0.63 | 40.58 | 0.38 |
| Oat straw | 90.8 | 1.20 | 38.64 | 0.76 |
| Soy-bean straw | 89.9 | 2.30 | 39.98 | 1.03 |
| Roots and tubers: | | | | |
| Potatoes | 21.1 | 1.36 | 16.43 | ........ |
| Beets | 13.0 | 1.21 | 8.84 | 0.05 |
| Mangel-wurzels | 9.1 | 1.03 | 5.65 | 0.11 |
| Turnips | 9.5 | 0.81 | 6.46 | 0.11 |
| Ruta-bagas | 11.4 | 0.88 | 7.74 | 0.11 |
| Carrots | 11.4 | 0.81 | 7.83 | 0.22 |
| Grains and other seeds: | | | | |
| Corn (average of dent and flint) | 89.1 | 7.14 | 66.12 | 4.97 |
| Kafir corn | 87.5 | 5.78 | 53.58 | 1.33 |
| Barley | 89.1 | 8.69 | 64.83 | 1.60 |
| Oats | 89.0 | 9.25 | 48.34 | 4.18 |
| Rye | 88.4 | 9.12 | 69.73 | 1.36 |
| Wheat (all varieties) | 89.5 | 10.23 | 69.21 | 1.68 |
| Cotton seed (whole) | 89.7 | 11.08 | 33.13 | 18.44 |
| Mill products: | | | | |
| Corn meal | 85.0 | 6.26 | 65.26 | 3.50 |
| Corn-and-cob meal | 84.9 | 4.76 | 60.06 | 2.94 |
| Oatmeal | 92.1 | 11.53 | 52.06 | 5.93 |
| Barley meal | 88.1 | 7.36 | 62.88 | 1.96 |
| Ground corn and oats, equal parts | 88.1 | 7.01 | 61.20 | 3.87 |
| Pea meal | 89.5 | 16.77 | 51.78 | 0.65 |
| Waste products: | | | | |
| Gluten meal— | | | | |
| Buffalo | 91.8 | 21.56 | 43.02 | 11.87 |
| Chicago | 90.5 | 33.09 | 39.96 | 4.75 |
| Hammond | 91.9 | 24.90 | 45.72 | 10.16 |
| King | 92.8 | 30.10 | 35.10 | 15.67 |
| Cream gluten (recent analyses) | 90.4 | 30.45 | 45.36 | 2.47 |
| Gluten feed (recent analyses) | 91.9 | 19.95 | 54.22 | 5.35 |
| Buffalo (recent analyses) | 91.0 | 22.88 | 51.71 | 2.89 |
| Rockford (Diamond) | 91.3 | 20.38 | 54.71 | 3.82 |
| Hominy chops | 88.9 | 8.43 | 61.01 | 7.06 |
| Malt sprouts | 89.8 | 18.72 | 43.50 | 1.16 |

[1] Corn fodder is entire plant, usually sown thick.
[2] Herd's grass of New England and New York.
[3] Lucern.

*Dry matter and digestible food ingredients in 100 pounds of feeding stuffs*—Continued.

| Feeding stuff. | Total dry matter. | Protein. | Carbohydrates. | Fat. | Fuel value. |
|---|---|---|---|---|---|
| Waste products—Continued. | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Calories.* |
| Brewers' grains (wet) | 24.3 | 4.00 | 9.37 | 1.38 | 30,692 |
| Brewers' grains (dried) | 92.0 | 19.04 | 31.79 | 6.03 | 119,990 |
| Distillery grains (dried), principally corn | 93.0 | 21.93 | 38.09 | 10.83 | 157,340 |
| Distillery grains (dried), principally rye | 93.2 | 10.38 | 42.48 | 6.38 | 125,243 |
| Atlas gluten feed (distillery by-product) | 92.6 | 23.33 | 35.64 | 11.88 | 159,818 |
| Rye bran | 88.2 | 11.47 | 52.40 | 1.79 | 126,352 |
| Wheat bran, all analyses | 88.5 | 12.01 | 41.23 | 2.87 | 111,138 |
| Wheat middlings | 84.0 | 12.79 | 53.15 | 3.40 | 136,996 |
| Wheat shorts | 88.2 | 12.22 | 49.98 | 3.83 | 131,855 |
| Buckwheat bran | 88.5 | 19.29 | 31.65 | 4.56 | 113,992 |
| Buckwheat middlings | 88.2 | 22.34 | 36.14 | 6.21 | 134,979 |
| Cotton-seed feed | 92.0 | 9.65 | 38.57 | 3.37 | 103,911 |
| Cotton-seed meal | 91.8 | 37.01 | 16.52 | 12.58 | 152,653 |
| Cotton-seed hulls | 88.9 | 1.05 | 32.21 | 1.89 | 69,839 |
| Linseed meal (old process) | 90.8 | 28.76 | 32.81 | 7.06 | 144,313 |
| Linseed meal (new process) | 90.1 | 30.59 | 38.72 | 2.90 | 141,155 |
| Sugar-beet pulp (fresh) | 10.1 | 0.63 | 7.12 | .......... | 14,415 |
| Sugar-beet pulp (dry) | 93.6 | 6.80 | 65.49 | .......... | 134,459 |
| Milk and its by-products: | | | | | |
| Whole milk | 12.8 | 3.38 | 4.80 | 3.70 | 30,829 |
| Skim milk, cream raised by setting | 9.6 | 3.10 | 4.61 | 0.90 | 18,139 |
| Skim milk, cream raised by separator | 9.4 | 3.01 | 5.10 | 0.30 | 16,351 |
| Buttermilk | 9.0 | 2.82 | 4.70 | 0.50 | 16,097 |
| Whey | 6.2 | 0.56 | 5.00 | 0.10 | 10,764 |

## FUEL VALUE.

The last column in the above table, headed "fuel value," indicates the heat and energy power of the food. As stated above, one of the primary functions of the food is to produce heat for the body and energy for work. The value of food for this purpose is measured in "heat units" or "calories,"[1] and is calculated from the nutrients digested. Thus the fuel power of 1 pound of digestible fat is estimated to be 4,220 calories, and of 1 pound of digestible protein or carbohydrates about 1,860 calories. The total fuel value of a feeding stuff is found by using these factors.

The meaning of the figures in the above table is that in 100 pounds of green corn fodder containing an average amount of dry matter (20.7 pounds) there are contained approximately 1.10 pounds of digestible protein (materials containing nitrogen), 12.08 pounds of digestible carbohydrates (starch, sugar, fiber, etc.), and 0.37 pound of digestible fat; and that these materials when consumed in the body will yield 26,076 calories of heat, furnishing energy for work and maintaining the temperature of the body.

## FOOD REQUIREMENTS OF ANIMALS.

It will be remembered that the primary functions of food are to repair the waste of the body, to promote growth in immature animals, and to furnish heat and energy. And for these purposes only the digestible portion of the food, as given in the above table, is to be taken into in practical experience that production has been increased and ch ened by making the rations conform more nearly to those sugge by the physiological standard.

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[1] A calorie of heat is the amount required to raise the temperature of a pound of water about 4° F.

## GERMAN STANDARDS.

The feeding standards prepared by Wolff, a German investigat animal nutrition, have been the most widely used of any. These based largely on the weight of the animal, although an attempt made to make allowance for the age of the animal and for the kin work performed. Of late, however, there has been a quite gen belief that the standards should take more account of the amoun character of production. In the case of milch cows, for exampl is thought that the standard should be adapted to the amount of produced, making the live weight a matter of secondary considerat The most important use of protein in feeding cows is in the forma of milk. Hence a cow producing 20 quarts of milk a day will req considerably more protein to elaborate this milk than one giving 8 quarts; and as the milk production of cows bears no particular tion to the live weight, a hundred pounds in weight more or less make very little difference in the ration. The use of rations var in accordance with the milk production is comparatively simple, only requires that the weight of milk given by different cows shal known. Wolff's standards have recently been modified by Prof Lehmann, as the result of additional experiments and practical e rience, and also in the attempt to adapt them more closely to the p tical needs of the animal. These standards are as follows:

*Wolff-Lehmann feeding standards.*

[Showing amounts of nutrients per 1,000 pounds live weight for a day's feeding.]

| Animal. | Total dry matter. | Digestible nutrients. | | | Fu va |
|---|---|---|---|---|---|
| | | Protein. | Carbohydrates. | Fat. | |
| Oxen: | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Calo* |
| At rest in stall | 18 | 0.7 | 8.0 | 0.1 | [illegible] |
| At light work | 22 | 1.4 | 10.0 | 0.3 | [illegible] |
| At medium work | 25 | 2.0 | 11.5 | 0.5 | [illegible] |
| At heavy work | 28 | 2.8 | 13.0 | 0.8 | [illegible] |
| Fattening cattle: | | | | | |
| First period | 30 | 2.5 | 15.0 | 0.5 | [illegible] |
| Second period | 30 | 3.0 | 14.5 | 0.7 | [illegible] |
| Third period | 26 | 2.7 | 15.0 | 0.7 | [illegible] |
| Milch cows: | | | | | |
| Giving 11 pounds milk a day | 25 | 1.6 | 10.0 | 0.3 | [illegible] |
| Giving 16½ pounds milk a day | 27 | 2.0 | 11.0 | 0.4 | [illegible] |
| Giving 22 pounds milk a day | 29 | 2.5 | 13.0 | 0.5 | [illegible] |
| Giving 27½ pounds milk a day | 32 | 3.3 | 13.0 | 0.8 | [illegible] |
| Sheep: | | | | | |
| Coarse wool | 20 | 1.2 | 10.5 | 0.2 | [illegible] |
| Fine wool | 23 | 1.5 | 12.0 | 0.3 | [illegible] |
| Breeding ewes, with lambs | 25 | 2.9 | 15.0 | 0.5 | [illegible] |
| Fattening sheep: | | | | | |
| First period | 30 | 3.0 | 15.0 | 0.5 | [illegible] |
| Second period | 28 | 3.5 | 14.5 | 0.6 | [illegible] |
| Horses: | | | | | |
| Light work | 20 | 1.5 | 9.5 | 0.4 | [illegible] |
| Medium work | 24 | 2.0 | 11.0 | 0.6 | [illegible] |
| Heavy work | 26 | 2.5 | 13.3 | 0.8 | [illegible] |
| Brood sows | 22 | 2.5 | 15.5 | 0.4 | [illegible] |

*Wolff-Lehmann feeding standards*—Continued.

| Animal. | Total dry matter. | Digestible nutrients. | | | Fuel value. |
|---|---|---|---|---|---|
| | | Protein. | Carbohydrates. | Fat. | |
| Fattening swine: | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Calories.* |
| First period | 36 | 4.5 | 25.0 | 0.7 | 57,800 |
| Second period | 32 | 4.0 | 24.0 | 0.5 | 54,200 |
| Third period | 25 | 2.7 | 18.0 | 0.4 | 40,200 |
| Growing cattle: | | | | | |
| Dairy breeds— | | | | | |
| 2 to 3 months old, weighing about 150 pounds | 23 | 4.0 | 13.0 | 2.0 | 40,050 |
| 3 to 6 months old, weighing about 300 pounds | 24 | 3.0 | 12.8 | 1.0 | 33,600 |
| 6 to 12 months old, weighing about 500 pounds | 27 | 2.0 | 12.5 | 0.5 | 29,100 |
| 12 to 18 months old, weighing about 700 pounds | 26 | 1.8 | 12.5 | 0.4 | 28,300 |
| 18 to 24 months old, weighing about 900 pounds | 26 | 1.5 | 12.0 | 0.3 | 26,350 |
| Beef breeds: | | | | | |
| 2 to 3 months old, weighing about 160 pounds | 23 | 4.2 | 13.0 | 2.0 | 40,450 |
| 3 to 6 months old, weighing about 330 pounds | 24 | 3.5 | 12.8 | 1.5 | 36,650 |
| 6 to 12 months old, weighing about 550 pounds | 25 | 2.5 | 13.2 | 0.7 | 32,150 |
| 12 to 18 months old, weighing about 750 pounds | 24 | 2.0 | 12.5 | 0.5 | 29,100 |
| 18 to 24 months old, weighing about 950 pounds | 24 | 1.8 | 12.0 | 0.4 | 27,350 |
| Growing sheep: | | | | | |
| Wool breeds— | | | | | |
| 4 to 6 months old, weighing about 60 pounds | 25 | 3.4 | 15.4 | 0.7 | 37,900 |
| 6 to 8 months old, weighing about 75 pounds | 25 | 2.8 | 13.8 | 0.6 | 33,400 |
| 8 to 11 months old, weighing about 80 pounds | 23 | 2.1 | 11.5 | 0.5 | 27,400 |
| 11 to 15 months old, weighing about 90 pounds | 22 | 1.8 | 11.2 | 0.4 | 25,850 |
| 15 to 20 months old, weighing about 100 pounds | 22 | 1.5 | 10.8 | 0.3 | 24,150 |
| Mutton breeds— | | | | | |
| 4 to 6 months old, weighing about 60 pounds | 26 | 4.4 | 15.5 | 0.9 | 40,800 |
| 6 to 8 months old, weighing about 80 pounds | 26 | 3.5 | 15.0 | 0.7 | 37,350 |
| 8 to 11 months old, weighing about 100 pounds | 24 | 3.0 | 14.3 | 0.5 | 34,300 |
| 11 to 15 months old, weighing about 120 pounds | 23 | 2.2 | 12.6 | 0.5 | 29,650 |
| 15 to 20 months old, weighing about 150 pounds | 22 | 2.0 | 12.0 | 0.4 | 27,750 |
| Growing swine: | | | | | |
| Breeding stock— | | | | | |
| 2 to 3 months old, weighing about 50 pounds | 44 | 7.6 | 28.0 | 1.0 | 70,450 |
| 3 to 5 months old, weighing about 100 pounds | 35 | 5.0 | 23.1 | 0.8 | 55,650 |
| 5 to 6 months old, weighing about 120 pounds | 32 | 3.7 | 21.3 | 0.4 | 48,190 |
| 6 to 8 months old, weighing about 200 pounds | 28 | 2.8 | 18.7 | 0.3 | 41,250 |
| 8 to 12 months old, weighing about 250 pounds | 25 | 2.1 | 15.3 | 0.2 | 33,200 |
| Growing fattening swine: | | | | | |
| 2 to 3 months old, weighing about 50 pounds | 44 | 7.6 | 28.0 | 1.0 | 70,450 |
| 3 to 5 months old, weighing about 100 pounds | 35 | 5.0 | 23.1 | 0.8 | 55,650 |
| 5 to 6 months old, weighing about 150 pounds | 33 | 4.3 | 22.3 | 0.6 | 52,000 |
| 6 to 8 months old, weighing about 200 pounds | 30 | 3.6 | 20.5 | 0.4 | 46,500 |
| 9 to 12 months old, weighing about 200 pounds | 26 | 3.0 | 18.3 | 0.3 | 40,900 |

For an unworked ox of 1,000 pounds the standard calls for 0.7 pound of digestible protein, 8 pounds of digestible carbohydrates, and 0.1 pound of digestible fat, which would furnish 16,600 calories of heat and energy. When heavily worked the same ox would require, accordng to the standard, food with four times as much protein and of nearly twice the fuel value. A cow giving 25 pounds of milk would require as much protein and about as much carbohydrates and fat as the heavily worked ox. A ration furnishing the protein, fat, and carbohydrates in the right proportion is said to be a "balanced" ration. If it contains too much carbohydrates and too little protein it is not well balanced.

In addition to furnishing the requisite amounts of nutrients the food must have a certain bulk. The required bulk is secured by feeding a certain amount of coarse fodder, which aids digestion and helps to keep the animal satisfied and healthy. The measure of the bulk or total solid matter is the weight of dry matter in the ration. The dry matter is the solid or water-free portion of the food. More latitude is allowable in this than in the case of any single nutrient.

## VALUE OF FEEDING STANDARDS.

It should be borne in mind that feeding standards are simply a concise and approximate statement of the amounts of the different nutrients required by animals, as indicated by the results of experiments and observation. They are not to be regarded as infallible or as absolute formulas which can be followed blindly without regard to the conditions. They are intended to apply to the average conditions. No single standard can be laid down for all conditions. Good judgment and intelligent observation on the part of the feeder are necessary in the application of feeding standards, as the calculation of economical rations is not merely a matter of applied mathematics. The local conditions as regards the feeding stuffs which can be grown and purchased economically, and the value of the products, will have much to do in determining how closely the feeder can afford to adhere to the standard. But such standards or formulas, used in connection with the feeder's observation of his animals and the markets, are very useful, and have served a good purpose in improving the practice of feeding. It is in their abuse that the chief danger lies.

## CALCULATION OF RATIONS.

The calculation of rations with the aid of the feeding standards and tables given above will prove both interesting and profitable, for it will throw much light on the proper combinations of food for different purposes. At the same time it promotes a spirit of inquiry and close observation on the part of the farmer, which is one of the first requisites of a successful feeder. The standard for a cow of 1,000 pounds weight, and giving 16½ pounds (about 8 quarts) of milk per day, calls for 2 pounds of protein, 11 pounds of carbohydrates, and 0.4 pound of fat, which would furnish 25,850 calories of heat. A ration can be made up furnishing approximately these amounts of protein, fat, and carbohydrates, but as the carbohydrates and fat serve practically the same purpose in nutrition, an excess of one may make up for a slight deficiency of the other.

## RATION FOR A DAIRY COW.

Let us calculate the daily ration for a cow giving about 8 quarts of milk a day, assuming that the farmer has on hand clover hay, corn fodder, corn meal, and wheat bran. From the table showing the amounts of digestible nutrients (p. 8) we find that 100 pounds of clover hay furnishes 7.38 pounds of protein, 38.15 pounds of carbohydrates, and 1.81 pounds of fat, equivalent to a fuel value of 92,324 calories. Ten pounds would have 0.74 pound of protein, 3.81 pounds of carbohydrates, and 0.18 pound of fat, giving a fuel value of 9,232 calories. In the same way the amounts furnished by 10 pounds of dry corn fodder, 3 pounds of corn meal, and 3 pounds of wheat bran are found. The result would be the following amounts:

*Method of calculating ration for dairy cow.*

| Ration. | Digestible protein. | Digestible carbohydrates. | Digestible fat. | Fuel value. |
|---|---|---|---|---|
| | *Pounds.* | *Pounds.* | *Pound.* | *Calories.* |
| 10 pounds clover hay | 0.74 | 3.81 | 0.18 | 9,232 |
| 10 pounds corn fodder | .23 | 3.23 | .11 | 6,936 |
| 3 pounds corn meal | .19 | 1.96 | .10 | 4,434 |
| 3 pounds wheat bran | .36 | 1.23 | .08 | 3,334 |
| Total | 1.52 | 10.23 | .47 | 23,936 |
| Standard for cow giving 8 quarts of milk a day | 2.00 | 11.00 | .40 | 25,850 |

This ration is below the standard, especially in protein. To furnish the protein needed without increasing the other nutrients too much, a feeding stuff quite rich in protein is needed. The addition of 2 pounds of Buffalo gluten meal would make the ration contain:

*Completed ration for dairy cow.*

| Ration. | Digestible protein. | Digestible carbohydrates. | Digestible fat. | Fuel value. |
|---|---|---|---|---|
| | *Pounds.* | *Pounds.* | *Pound.* | *Calories.* |
| 10 pounds clover hay, 10 pounds corn fodder, 3 pounds corn meal, and 3 pounds wheat bran | 1.52 | 10.23 | 0.47 | 23,936 |
| 2 pounds Buffalo gluten meal | .43 | .86 | .23 | 3,404 |
| Total | 1.95 | 11.09 | .70 | 27,340 |

This gives nearly the amounts of the several nutrients called for by the standard, although it contains a little more fat, the effect of which is shown in increasing the fuel value above the standard slightly. The ration conforms sufficiently close to the standard, however, and as near as will often be practicable. Although a calculation of the dry matter would show it to be somewhat below the standard, the bulk material furnished is ample, and there would be no advantage in increas ing it by feeding some very coarse material, like straw or swale hay, in place of a part of the corn fodder or hay.

Since the prime objects of food are to repair the waste of the bo (or promote growth) and produce heat and energy, the calculation ma be considerably simplified by considering only the protein and th fuel value, without impairing accuracy. For example, suppose it i desired to calculate a ration for cows giving about 22 pounds (1 quarts) of milk a day, the supply of feeds being timothy hay, co silage, corn, bran, and Chicago gluten meal:

*Simplified calculation of ration for cows.*

| Ration. | Protein. | Fu valu |
|---|---|---|
| | *Pounds.* | *Calori* |
| 8 pounds rowen hay | 0.58 | [illegible] |
| 30 pounds silage | .36 | [illegible] |
| 3 pounds corn meal | .19 | [illegible] |
| 4 pounds bran | .48 | [illegible] |
| 3 pounds Chicago gluten meal | .99 | [illegible] |
| Total | 2.60 | [illegible] |
| Standard ration | 2.50 | [illegible] |

This is slightly in excess of the standard, but the proportion is rig so that a little less of the ration might be fed and still meet its requir ments. However, as mentioned above, such calculations are n mathematically accurate, owing to variations in the composition a digestibility of feeding stuffs at different times, nor are the so-term standards exact, but merely approximate statements of the gener requirements of animals. It is useless to attempt, therefore, to calc late the ration to hundredths of a per cent. The most that can safely done is to compound a well-balanced ration, and then by clos watching the cows add to or reduce it, as seems to suit the case of t individual animals, or groups of animals, as indicated by their prod tion and their general condition. It is granted, of course, that feeding formulas can take the place of the good judgment of t feeder. They are merely aids in that direction.

**Adjustment of ration to milk yield.**—In making allowance for the d ference in milk yield of different cows, a uniform basal ration can fed to all the cows, and the amount of the richer grain mixture var to suit the demands. For example, a basal ration might be made of 25 pounds of corn silage, 8 pounds of rowen hay, and 3 pou each of corn meal and wheat bran, which would supply 1.43 pounds protein and a fuel value of 23,712 calories. To this could be add richer grain mixture composed of two parts of gluten meal and part of cotton-seed meal, the amount of this being varied accordin e milk yield of the cow. Two pounds of this mixture would bring e ration up to 1.97 pounds of protein and 26,999 calories, which ould meet the requirements of cows giving 12 to 15 pounds of milk day, while 4 pounds would bring it up to 2.50 pounds of protein and 0,286 calories of heat, suitable for the cows giving 20 to 25 pounds of ilk, and so on, 5 or 6 pounds of the grain mixture being fed to the eavier milkers.

### RATION FOR STEERS.

A ration composed of 10 pounds of shelled corn, 5 pounds of wheat bran, 2 pounds of linseed meal (new process), and 10 pounds of corn fodder per steer would furnish the following amounts of protein and energy:

*Calculated ration for steers.*

| Ration. | Protein. | Fuel value. |
|---|---|---|
| | *Pounds.* | *Calories.* |
| 10 pounds shelled corn | 0.71 | 15,722 |
| 5 pounds bran | .60 | 5,557 |
| 2 pounds linseed meal | .61 | 2,823 |
| 10 pounds corn fodder | .23 | 6,936 |
| Total | 2.15 | 31,038 |

This would correspond approximately to the requirements of yearling steers. The exclusive feeding of shelled corn, as is often practiced in the middle West, gives a poorly balanced ration, as it is not possible to compound a ration of corn and corn fodder or common hay which will not contain a disproportionate amount of fat and carbohydrate constituents. Admixtures of other grains or by-products give better balanced rations, and such rations have usually been found more profitable. Local conditions, however, and the practice of following steers with hogs may alter this.

### COTTON-SEED MEAL AND HULLS.

A common practice in fattening steers in the South is to feed 15 to 24 pounds of cotton-seed hulls and 6 to 8 pounds of cotton-seed meal. The nutrients contained in such mixtures are compared with the standard in the following table:

*Rations fed to steers in the South.*

| Ration. | Dry matter. | Digestible protein. | Digestible carbohydrates. | Digestible fat. | Fuel value. |
|---|---|---|---|---|---|
| | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Calories.* |
| 20 pounds hulls and 6 pounds cotton-seed meal | 23.79 | 2.43 | 7.43 | 1.13 | 23,108 |
| 20 pounds hulls and 8 pounds cotton-seed meal | 25.12 | 3.17 | 7.76 | 1.38 | 26,153 |
| 24 pounds hulls and 6 pounds cotton-seed meal | 26.84 | 2.47 | 8.72 | 1.21 | 25,920 |
| 24 pounds hulls and 8 pounds cotton-seed meal | 28.68 | 3.21 | 9.05 | 1.46 | 28,965 |
| Wolff-Lehmann standard: | | | | | |
| First period | 30 | 2.5 | 15.0 | .5 | 34,650 |
| Second period | 30 | 3.0 | 14.5 | .7 | [illegible] |
| Third period | 26 | 2.7 | 15.0 | [illegible] | [illegible] |

## WEIGHT OF ONE QUART OF FEEDING STUFFS.

In calculating rations it is necessary to use weights rather than measures, as the analyses and tables are made on the basis of weight. As the farmer measures the grain given it will be necessary to ascertain the relation between the amount to be given and its measure. For this purpose the following table, showing the weight per quart of a number of feeding stuffs, may be helpful:

*Weight of feeding stuffs per quart.*

| Feeding stuff. | Pound. | Ounces. |
|---|---|---|
| Corn, cracked | 1 | 12 |
| Corn meal | 1 | 8 |
| Corn-and-cob meal | 1 | 6 |
| Oats, whole | 1 | ...... |
| Oats, ground | ...... | 12 |
| Wheat, whole | 1 | 14 |
| Wheat bran | ...... | 10 |
| Wheat bran, coarse | ...... | 8 |
| Wheat middlings | 1 | 2 |
| Wheat middlings, coarse | ...... | 13 |
| Rye bran | ...... | 10 |
| Gluten meal | 1 | 11 |
| Gluten feed | 1 | 3 |
| Linseed meal | 1 | 2 |
| Cotton-seed meal | 1 | 8 |

Some of these materials, especially by-products like wheat bran, vary considerably in weight, and the above figures can not be regarded as strictly accurate for all cases. Weighing is, of course, always the safer way where it is desired to feed quite definite amounts.

## SELECTION OF FEEDING STUFFS.

In selecting feeding stuffs for his stock the farmer will naturally be governed by the conditions of the market. The cost of feeding stuffs is controlled by other factors than the actual amounts of food materials which they contain; indeed, there often appears to be very little connection between the two. Bearing in mind that the protein is the most expensive ingredient, and the one especially sought in concentrated feeds, the farmer can make his selection with the aid of the tables showing the digestible materials in 100 pounds. These will show him whether wheat at 50 cents per bushel is a cheaper feed than corn at 60 cents, and how gluten meal at $23 per ton compares with linseed meal at $27. In these comparisons only the protein and fuel value need necessarily be considered. Of course the special adaptability of some materials to different kinds of animals and different purposes will be taken into account.

## MANURIAL VALUE.

But another important consideration where fertilizers or manures have to be relied upon is the manurial value of a feeding stuff [illegible] This is shown by the nitrogen in the protein and the phosphori [illegible] potash in the ash. Feeding stuffs differ widely [illegible] resp bran and cotton-seed meal having a high manurial value, while that of corn meal is relatively low. The value of the manure is largely determined by the character of the food given. If the manure is carefully preserved a large proportion of the fertilizing constituents of the feed is recovered in the manure, and goes to enrich the land. This matter has been treated in a separate bulletin on barnyard manure.[1]

It will be seen by referring to the table of feeding stuffs given above that hay from the leguminous crops—clover, lupines, alfalfa, cowpea, etc.—contains about twice the quantity of digestible protein that hay from the grasses does. As a result the former contains much more nitrogen for fertilizing purposes, and is also somewhat richer in potash than grasses. The seeds of these plants (cowpea, soy bean, etc.) are exceedingly rich in protein and can take the place of expensive commercial feeds. By growing and feeding more leguminous crops the amount of grain required is diminished, the value of the manure is increased, and the soil is enriched in fertility. Further than this, it has been demonstrated within the last few years that leguminous crops are able to derive the larger part of this nitrogen from the atmosphere during their growth, requiring little manuring with nitrogenous manures. They therefore enrich the soil, the ration, and the manure in nitrogen which they derive from the atmosphere without cost to the farmer, besides improving the mechanical and physical condition of the soil.[2]

## ORIGIN OF BY-PRODUCTS USED AS FEEDING STUFFS.

The by-products resulting from the manufacture of flour, glucose, starch, fermented liquors, etc., are extensively used for feeding purposes, and include many of the richest and most prized feeding stuffs. The manner in which these materials are produced will be briefly described.

**By-products from flouring mills.**—In the modern processes of making flour from wheat the grain is subjected to successive crushings or grindings. After each of these, the products are separated by screening and blowing into flour, middlings, and bran. The bran consists of the coarser parts of the husk, which are unfit for further grinding, with portions of the gluten layer. The middlings contain small particles of bran as admixtures. These are separated, and go under the name of shorts. The shorts contain less fiber and ash than the bran, although they are of similar origin—the outer coats of the grain. After cleaning, the middlings are graded and reground to flour.

By-products of similar nature result in the milling of rye, buckwheat, rice, etc.

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[1] Farmers' Bulletin No. 21.

[2] See also Farmers' Bulletin No. 16, Leguminous Crops for Green Manuring and for Feeding, by the author of this bulletin.

Hominy chop, meal, and feed result from the manufacture of hominy, and contain the germ and coarser portions of the corn.

**By-products from glucose and starch factories.**—These include so-called gluten meal, glucose meal, cream gluten, gluten flour, gluten feed, glucose feed, dried sugar feed or meal, maize feed, dried starch feed, and some other materials of similar nature. These are all obtained as by-products in the manufacture of starch and glucose from the starch of corn. The process followed and the treatment of the by-products differs considerably in different factories, which accounts for the wide variations in their composition.

The corn is soaked until it is swollen and soft, and is passed through the mill while wet, the hulls and germs of the corn being rubbed off. In some cases the starch is separated from this mass by means of running water, and the wet residue is dried and sold as gluten feed. In other cases the mass after grinding is bolted, the starch and gluten passing through while the husk and germ remain behind. In some factories the latter (husk and germ) are dried and sold as corn-germ feed, corn-germ meal, etc. In others the material is treated to extract the oil from the germ and then sold under the name of maize feed. The material which passes the bolting cloth is treated to separate most of the starch, and the residue is sold as gluten meal, cream gluten, etc. The Chicago gluten meal, it is said, has had a part of the fat extracted from it. In some cases the gluten meal is mixed with the hulls and germs without the oil being extracted. This is said to be the case with Buffalo gluten feed.

The residues from these factories are frequently sold in their wet condition, containing from 60 to 70 per cent of water, under the names wet starch feed, sugar feed, glucose feed, etc. These wet products must be used at once, as they ferment. The dried products from the same factory often vary considerably in composition from time to time. Owing to these variations and the fact that there is such a variety of names for these products that it is difficult to make any helpful classification, the farmer can only be certain of what he is buying when he buys on a guaranty of composition or from lots that have been analyzed.

**By-products from oil mills.**—Of these the most common in this country are the cotton-seed meal and linseed meal. The oil is expressed from the hot cotton seed, and the hard cakes remaining are called oil cakes. In Europe this cake is often sold as such for feeding. In this country it is usually ground to a meal.

The composition of cotton-seed meal depends upon the composition of the seed and the completeness of the separation of the hulls and the expression of the oil. The composition of the hulls depends considerably upon the thoroughness with which the kernel and lint are removed. Usually more or less of the kernel adheres to the hulls, increasing the percentage of protein and fat. Linseed meal, or oil meal, as it is often called, is the residue from the separation of oil from flax seed, and is distinguished as old process and new process. In the old process the oil is expressed. In the new process it is more thoroughly removed with the aid of solvents, hence the meal contains less fat.

**By-products from breweries and distilleries.**—In making malted liquors from grain (usually barley) the grain is malted or allowed to sprout, resulting in the development of diastase, which converts the starch of the grain into sugar. When the process has proceeded far enough it is checked by kiln-drying, the sprouts being removed by machinery and sold for feed under the name of malt sprouts. The grain (then known as malt) is treated with water and the clear wort subsequently drawn off and fermented. The residue of the grain, known as brewers' grains, consists of the hull, germ, gluten, and some of the starch of the grain. It is sometimes sold in the wet condition for immediate use, but when it is to be shipped away is dried, and can then be kept indefinitely.

In making distilled liquors from corn, rye, or other grain, the ground grain is treated with a solution of malt to change the starch into sugar, which is then fermented with yeast and distilled. The residue, or distillery slop, is sometimes fed as such, but, like wet brewers' grains, spoils quickly. It is filtered and dried, and yields a rich distillery feed or distillers' grains. Distinction is made between the grains from corn and from rye, those from corn being the richer in protein and fat. Atlas gluten meal and feed, Golden Gluten, and Grano Gluten are all distillery products and do not properly belong with the gluten meals and feeds, as their names would imply.

### SUGAR-BEET PULP AND MOLASSES.

The establishment of beet-sugar factories in this country has led to the production of immense quantities of sugar-beet pulp as a waste material. This is sometimes called "diffusion residue," or "beet chips." It consists of the residue of the beet after the extraction of the sugar under pressure in the diffusion batteries. With the sugar more or less of the other soluble constituents are taken out, and hence the residue is to be regarded as somewhat inferior to the beet before extraction, containing more of the fiber and gums and less soluble constituents. The pulp contains about 90 per cent of water as it comes from the factory. On this account it can not profitably be shipped or hauled any great distance. In some European factories it is dried, but this process is expensive and has not been adopted to any extent in this country. The fresh pulp can frequently be drawn home from the factory at the time the beets are being hauled. Many of the factories have been willing to give it away in order to get rid of it, while others which have a greater demand for it sell it for 50 cents ton. Still other factories have put up feeding sheds near by, where hundreds of steers and sheep are fed largely upon the pulp with the addition of a little hay.

**Results of feeding beet pulp.**—One large factory in Nebraska, which has a farm of 12,000 acres connected with it, has erected barns and sheds to accommodate about 16,000 head of sheep. During the season of 1900 this factory fed 32,000 head of sheep. This factory, running at its full capacity, it is expected would furnish feed for about 10,000 head of steers and 50,000 sheep. The manager is a firm believer in the value of beet pulp as a succulent food. He states that he "never saw sheep do better," and when ready for the market they were well fattened, thick-fleshed, plump, and in prime condition. The meat was juicy and of excellent quality.

Prof. Thomas Shaw expresses his belief that sugar-beet pulp can be fed more advantageously to cattle and sheep that are being fattened than to dairy cows. The New York Cornell Experiment Station, however, found that this material gave good results with milch cows, the dry matter (solids) in it being about equal in value to that in corn silage. German experiments with beet pulp for cows have also given good results, the flow of milk being maintained in a satisfactory manner. Some Danish experiments have shown that, as compared with mangels, the butter produced on sugar-beet pulp was of about equal quality and kept fully as well. Where large quantities of the pulp were fed the cream required to be churned a few minutes longer.

In practice, about 10 pounds of pulp per day is fed to sheep, and 50 to 75 pounds to cattle. The amount in the latter case, however, is said to depend on the cattle, and more may be given, up to 100 pounds, if they will eat it. The pulp is believed to effect a considerable saving in the amount of grain required for fattening.

**Preservation in silos.**—Sugar-beet pulp can be successfully preserved in silos and makes a very fair quality of silage. It is relished by cattle, even the slightly spoiled portions not being distasteful to them. In Europe the silos consist of trenches or pits dug in the ground, but the ordinary silo used in making corn silage will undoubtedly preserve the material with less loss.

**Benefits of feeding pulp.**—As the sugar-beet crop is an exhaustive one, and the fertility of the soil can be maintained by feeding the pulp, it becomes quite an important matter that farmers growing sugar beets should combine with it the feeding of the pulp where practicable. Prof. W. A. Henry states as his belief that "a farming community which will intelligently grow beets and utilize the pulp resulting from them in the feeding of cattle, will be able to grow as large crops in addition to the beets as were produced before adding that industry, and to maintain more cattle than was possible before beet farming was inaugurated. This statement is warranted by the condition vailing in the beet districts of Europe. Beet culture means cattle and larger crops generally, rather than less, provided a that the pulp from the beets is properly utilized."

### SUGAR-BEET MOLASSES.

This is another product of the beet-sugar manufacture, which mulates in large quantities. On account of the salts which i tains, this molasses can not be disposed of for human consum It has a bitter taste and is purging in its effects. In Europe been found to possess considerable value for feeding. For thi pose it has been mixed with peat, dried blood, beet pulp, or mixture of feeding stuffs, such as bran and palm-nut meal, in that it might be more conveniently handled. The molasses co from 40 to 50 per cent of sugar, which is all digestible, and it is this constituent that its feeding value almost entirely depend European experiments no deleterious results have been noticed when 4 or 5 pounds of molasses per day was fed. It has given results with milch cows and is regarded as an excellent food for h being readily eaten. Experiments in feeding it to steers at the ada Experimental Farms were favorable to its use, as the a became very fond of it and it stimulated their appetite.

### PREPARATION OF FOOD FOR ANIMALS.

One point upon which there seems to be much misunderstandin to the influence of previous treatment of the food on its digesti Thus, for example, the effect of drying hay is not to lessen its di bility, as is often believed. The soluble materials may be washe if the hay is rained upon, and the tender parts may be lost in harve but in ordinary haymaking the water of the grass is largely drie without the digestibility of the constituents being materially aff Hay stored for a long time, even when kept dry and not allow heat, appears to lose a part of its value as food.

### COOKING AND STEAMING FOOD.

There has been considerable misconception as to the value of ing or steaming food for stock. Experiments abroad have indi that cooking or steaming coarse or unpalatable food was advanta not on account of making the food more nutritious, but in inducin animals to eat larger quantities of it. In fact it has been show lupine hay and some other materials that the digestibility of c of the food ingredients, notably the albuminoids, was diminishe steaming; and the cooking of potatoes, which was formerly bel advantageous, has been shown to be of no advantage whatever i of milch cows, although it was of some advantage to pigs. Julius Kühn, in his book on feeding, says:

> Unless large amounts of straw and coarse foods are to be fed and the supply of good hay and hoed crops is scarce, it will usually be more profitable to omit the steaming. If the reverse condition prevails, steaming will be found a very advantageous means of inducing the animals to eat sufficiently large quantities of the food.

Ladd, while connected with the New York State Station, reported analyses of cooked and uncooked clover hay and corn meal, and determinations of the digestibility of the same. These showed that the percentage of albuminoids and fat and the relative digestibility of the albuminoids were more or less diminished by cooking.

**Cooking grain.**—The experiments made by our experiment stations in preparing food have been mostly with pigs. At least thirteen separate series of experiments in different parts of this country have been reported on the value of cooking or steaming food for pigs. In these, cooked or steamed barley meal, corn meal, and shorts; whole corn; whole corn and shorts; peas, corn and oatmeal; potatoes, and a mixture of peas, barley, and rye have been compared with the same foods uncooked (and usually dry). In ten of these trials there has not only been no gain from cooking, but there has been a positive loss, i. e., the amount of food required to produce a pound of gain was larger when the food was cooked than when it was fed raw, and in some cases the difference has been considerable. In the three exceptional cases there was either no gain at all or only very slight gain from cooking or steaming, amounting to 2 per cent in one case.

**Steaming cotton seed.**—Experiments in feeding steamed cotton seed to cows are reported by the Mississippi Station. The station concludes from three years' work that "the milk and butter from cows fed on steamed cotton seed cost less than that from cows fed on raw cotton seed and but little more than one-half as much as that from cows fed on cotton-seed meal. The butter from steamed cotton seed is superior in quality to that from either raw seed or cotton-seed meal." The Texas Station finds it advantageous to boil cotton seed for steers.

### MOISTENING AND SOAKING FOOD.

Three stations have reported comparisons of dry with wet or soaked food for pigs. The food consisted of shelled corn in one case, of a mixture of corn meal and shorts in another, and of a mixture of corn meal, shorts, and linseed meal in a third. In every case the pigs ate more of the wet food and made larger gains on it. The additional gain was usually due to the larger amount of food eaten when moistened or soaked. The Kansas Station has just reported an experiment in soaking corn for steers. The shelled corn for one lot (5 steers) was soaked until it began to soften, and that for the other lot (5 steers) was fed dry. From November 7 to April 6 the lot on soaked corn ate 282 bushels of corn and gained 1,632 pounds, while the other lot ate 290 bushels of corn and gained only 1,468 pounds—a difference of 164 pounds. Owing to their better condition the steers fed soaked corn brought a higher price, giving a balance of $25.50 in favor of soaking. The conclusion is that it will pay to soak corn for steers if it can be done for 6 cents a bushel. Soaking wheat for pigs is quite generally recommended.

### CUTTING COARSE FODDER.

The Maine Station compared the value of chopped and unchopped hay for cows, and found no evidence that the chopping had any effect. The Indiana Station found that steers made better gains on cut than on uncut clover hay. Cutting corn stover was found advantageous at the Wisconsin Station. In reference to cutting coarse fodder Professor Henry says:

> There should be a good feed cutter on every dairy farm, useful for silo filling in the fall and for chaffing feed in the winter. All cornstalks should be put through this machine, for then they are in better condition for feeding, and the coarser portions left uneaten are in good form for bedding and the manure heap. Long cornstalks are a nuisance in the feeding manger, worthless for bedding, and troublesome in the manure pile. Many farmers find difficulty in feeding cut cornstalks, since sometimes the cows refuse to eat them. In a few cases we have found that the sharp ends of the cornstalks, when cut certain lengths, injure the mouths of the cows. Where they are not well eaten the cause is often due to overfeeding, or endeavoring to have the cows live on too limited a variety of foods. Keep the mangers clean and feed the cut fodder with care, and usually very little will be left over, and that only the coarsest portion. Experiments at the Wisconsin Station show that with the varieties of corn raised there much more of the cut stalks will be eaten than if fed uncut under the same conditions.

### THE VALUE OF SUCCULENT FEEDS.

The use in this country of some kind of succulent feed nearly the whole year round, to keep up the appetite and the general condition of the animals, has become quite general. In Europe roots are largely grown for this purpose. In this country roots are not grown to any great extent in comparison with corn, which furnishes a larger and cheaper supply of food material from a given area than any other crop. The work of the experiment stations has shown that fodder corn yields about twice as much dry matter as a crop of roots grown on the same land. While the dry matter in beet roots is somewhat more digestible than that in corn silage, it has been found in feeding experiments that dairy cows fed rations consisting quite largely of either beets or silage have given rather better returns for the dry matter in the silage. The loss of nutrients in preserving corn in the form of silage and as dry corn fodder is about the same when careful methods are employed, but feeding trials with dairy cows have shown that silage gives rather better results than a corresponding amount of dry corn fodder. Furthermore, there is less waste in feeding it, as the animals eat the butts readily in the form of silage, but reject them in the form of corn fodder, even when cut fine. Silage proves more acceptable to stock than dry fodder, and they will consume a larger amount of dry matter in that form.

The use of succulent food in the form of corn silage has, therefore, become very prevalent in localities where corn is a leading forage crop. It is found adapted to nearly all kinds of farm animals, including horses, sheep, and pigs.

## SOILING.

This term is used to mean the feeding of farm animals, more or less confined, on green forage fresh from the fields. The practice is more prevalent in older countries where land is expensive, and is coming into use in some localities in the eastern part of this country to such an extent as to entitle it to recognition as one of the systems of feeding. Partial soiling is much more common, being relied upon to carry the animals over a period when pastures are short. Under the soiling system a larger number of animals can be kept upon a given acreage, and by allowing open-air exercise in a large yard or pasture the practice has been demonstrated as entirely feasible for dairy animals.

## SOILING DAIRY COWS.

The Wisconsin Station found that 1 acre of soiling crops was equal to about 2½ acres of good blue-grass pasture for feeding dairy cows, and the Connecticut Storrs Station kept 4 cows from June 1 to November 1 on soiling crops produced on 2½ acres of land.

The New Jersey Experiment Station has been conducting a practical trial in soiling dairy cows for a number of years past, and finds that complete soiling is entirely practicable, i. e., that green forage crops may serve as the sole food of the dairy herd, aside from the grain ration, without injury to the animals and with a considerable saving in the cost of milk. A forage-rotation system has been worked out so as to furnish a continuous supply of green crops throughout the season. One acre of soiling crops produced sufficient fodder for an equivalent of 3½ cows for six months. Rye, corn, crimson clover, alfalfa, oats and peas, and the millets have been found to furnish food more economically than any other green crops in that locality. A grain ration was always fed in addition to the soiling crops.

The station holds that "where complete soiling is not practicable it will pay to grow forage crops to supplement pasturage during drought or shortage due to other causes, and thus furnish a sufficient and continuous supply of food from the farm." The added labor involved in growing and harvesting these green crops should be taken account of. As an average cow or steer will consume from 60 to 100 pounds of green forage a day, the labor involved in supplying green food for a large herd is quite an item. Partial soiling properly conducted will be found a profitable practice on many farms, enabling more stock to be kept and maintaining a continuous flow of milk, and good growth in the case of steers, throughout the season when pastures are likely to be short.

## CONDIMENTAL FEEDING STUFFS.

A considerable number of proprietary articles sold under trade names are found on the markets in this country. Judging from the extent to which they are advertised and statistics which have been collected from feeders, the employment of these prepared or condimental feeds must be quite extensive. Extravagant claims are made for them as to their effect upon the general health of animals and their feeding value or their ability to increase milk production. Tonic or medicinal properties are claimed for many of them. They frequently contain a large quantity of salt, some fenugreek, aromatic seeds, charcoal, Epsom salts, sulphur, cayenne, gentian, ginger, etc.

Analyses of samples of these feeding stuffs collected from time to time show that none of them can be regarded as concentrated feeds in the common acceptation of the term. The basis of the better ones is linseed or flaxseed meal or some cereal by-product. They are usually sold at exorbitant prices, ranging from 10 to 20 cents a pound. Neither the claims made for their valuable properties nor the need of supplying tonics or medicines with the food will justify the feeder in buying such materials. The Connecticut State Experiment Station has recently exposed a number of these condimental feeds for which claims wholly without ground were made.

The mildly curative properties of the various drugs used in these feeds are well understood by most dairy farmers, as well as their limitations. The claims that by the use of condiments and spices the digestibility of food can be increased, and in this way a saving of feeding can be effected, have no basis in fact. No experiments have demonstrated or made even probable such an effect.

## INSPECTION OF FEEDING STUFFS.

A number of the Eastern States have passed laws requiring that the composition of certain classes of feeding stuffs be guaranteed by the manufacturers, and providing an inspection of these goods to see that the guaranty is complied with. These laws apply only to the so-called concentrated feeding stuffs, especially the by-products and mixed feeds, not the cereal grains sold as such. The inspection is usually in charge of the experiment station and is managed very similarly to the fertilizer inspection. The results are published in bulletins, which enable the farmer to judge as to the reliability of these goods and assist him in making an economical selection.

## NECESSITY FOR INSPECTION.

The need for this inspection arises from the quite wide variation in the composition of many of the by-products, the confusion of names, as in the case of the by-products from starch manufacture, the large number of mixed feeds which are put upon the market under proprietary names, and the occasional tendency to mix with the material substances of inferior value. The variation which occurs in the composition of some of the most common concentrated feeding stuffs is readily shown by the compilation of analyses given at the end of this bulletin. Wheat bran, for example, varies in protein all the way from 12 to 19 per cent, wheat middlings from 10 to 20 per cent, buckwheat middlings from 25 to 31 per cent, cotton-seed meal from 23 to 50 per cent, etc., while the various materials sold under the name of gluten meal have been found to vary from less than 20 to over 40 per cent. These variations are, for the most part, due to slight differences in the method of treatment and in the original material used rather than to adulteration, but they are none the less misleading to the farmer.

In the trade names which have been given to the different by-products great confusion has arisen, so that only one familiar with the processes of manufacture could tell the class to which the different materials belong. In some cases the names appear to have been purposely made delusive.

Of recent years there have been a large number of mixed stock feeds placed upon the market for which extraordinary claims have often been made. Some of these serve as an outlet for the light oats and hulls from oatmeal factories, and other by-products. One so-called concentrated dairy feed recently reported upon contained, on the average, less than 8 per cent of protein and 3.4 per cent of fat, while it had over 22 per cent of fiber, which warrants the conclusion that it is "concentrated" in fiber chiefly.

No very considerable amount of actual adulteration has been observed in this country, although ground cotton-seed hulls have been mixed with cotton-seed meal and peanut shells, oat hulls, and similar products with other materials in a manner that must be considered adulteration.

## SOME RESULTS OF INSPECTION.

The feeding stuff inspection protects the farmer from fraud in the same way that the fertilizer inspection does, and gives him the benefit of a guaranteed composition in buying. The result of this inspection, which has been in operation for a number of years, has been quite marked in driving inferior grades of goods, like adulterated cotton-seed meal, out of the market, and tending to bring about greater uniformity in composition in the case of standard by-products.

## APPENDIX.

### COMPOSITION OF FEEDING STUFFS.

In the following table the composition of a large number of feeding stuffs in common use is given from American sources, previous tables being revised for this purpose. Not only are the averages given, but also the highest and lowest result found for each ingredient in the various materials. That is, in the case of the minimum and maximum the figures given do not represent the results of single analyses, but are the highest and lowest results which have been found in the case of each ingredient. They are given to show the limits within which each ingredient has been found to vary.

*Composition of feeding stuffs.*

| Feeding stuff. | Water. | Ash. | Protein. | Fiber. | Nitrogen-free extract. | Fat. | Number of analyses. |
|---|---|---|---|---|---|---|---|
| GREEN FODDER. | | | | | | | |
| Corn fodder:[1] | | | | | | | |
| Flint varieties— | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | |
| Minimum | 51.5 | 0.7 | 0.6 | 2.1 | 4.3 | 0.3 | |
| Maximum | 90.8 | 1.8 | 4.0 | 11.4 | 36.3 | 1.3 | |
| Average | **79.8** | **1.1** | **2.0** | **4.3** | **12.1** | **0.7** | 40 |
| Flint varieties cut after kernels had glazed— | | | | | | | |
| Minimum | 69.7 | 0.9 | 1.5 | 3.0 | 10.0 | 0.6 | |
| Maximum | 83.7 | 1.7 | 2.7 | 6.1 | 19.7 | 1.3 | |
| Average | **77.1** | **1.1** | **2.1** | **4.3** | **14.6** | **0.8** | 10 |
| Dent varieties— | | | | | | | |
| Minimum | 59.5 | 0.6 | 0.5 | 2.0 | 3.0 | 0.1 | |
| Maximum | 93.6 | 2.5 | 3.8 | 11.0 | 27.0 | 1.6 | |
| Average | **79.0** | **1.2** | **1.7** | **5.6** | **12.0** | **0.5** | 63 |
| Dent varieties cut after kernels had glazed— | | | | | | | |
| Minimum | 59.5 | 1.0 | 1.0 | 5.4 | 11.6 | 0.4 | |
| Maximum | 80.7 | 2.2 | 3.3 | 8.5 | 27.0 | 1.6 | |
| Average | **73.4** | **1.5** | **2.0** | **6.7** | **15.5** | **0.9** | 7 |
| Sweet varieties— | | | | | | | |
| Minimum | 69.3 | 0.8 | 0.9 | 1.9 | 3.2 | 0.1 | |
| Maximum | 92.9 | 2.6 | 2.7 | 8.5 | 19.4 | 1.0 | |
| Average | **79.1** | **1.3** | **1.9** | **4.4** | **12.8** | **0.5** | 21 |
| All varieties— | | | | | | | |
| Minimum | 51.5 | 0.6 | 0.5 | 1.9 | 3.0 | 0.1 | |
| Maximum | 93.6 | 2.6 | 4.0 | 11.4 | 36.3 | 1.6 | |
| Average | **79.3** | **1.2** | **1.8** | **5.0** | **12.2** | **0.5** | 120 |
| Leaves and husks, cut green— | | | | | | | |
| Minimum | 57.9 | 2.1 | 1.8 | 6.6 | 16.7 | 1.0 | |
| Maximum | 71.3 | 4.4 | 2.4 | 12.5 | 22.2 | 1.3 | |
| Average | **66.2** | **2.9** | **2.1** | **8.7** | **19.0** | **1.1** | 4 |
| Stripped stalks, cut green— | | | | | | | |
| Minimum | 74.5 | 0.6 | 0.4 | 6.7 | 14.2 | 0.4 | |
| Maximum | 77.4 | 0.8 | 0.6 | 8.8 | 16.0 | 0.6 | |
| Average | **76.1** | **0.7** | **0.5** | **7.3** | **14.9** | **0.5** | 4 |
| Kafir corn: | | | | | | | |
| Minimum | 60.5 | 1.0 | 1.2 | 3.7 | 6.1 | 0.3 | |
| Maximum | 87.6 | 2.7 | 3.8 | 9.5 | 25.8 | 1.5 | |
| Average | **73.0** | **2.0** | **2.3** | **6.9** | **15.1** | **0.7** | 27 |
| Rye fodder: | | | | | | | |
| Minimum | 74.4 | 1.3 | 2.3 | 4.7 | 4.9 | 0.2 | |
| Maximum | 84.3 | 2.4 | 3.0 | 14.9 | 12.4 | 0.7 | |
| Average | **76.6** | **1.8** | **2.6** | **11.6** | **6.8** | **0.6** | 7 |

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[1] Corn fodder is the entire plant, usually a thickly planted crop. Corn stover is what is left after the ears are harvested.

*Composition of feeding stuffs*—Continued.

| Feeding stuff. | Water. | Ash. | Protein. | Fiber. | Nitrogen-free extract. | Fat. | Number of analyses. |
|---|---|---|---|---|---|---|---|
| GREEN FODDER—continued. | | | | | | | |
| Oat fodder: | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | |
| Minimum | 31.3 | 1.5 | 1.5 | 7.1 | 10.8 | 0.4 | ........ |
| Maximum | 78.6 | 4.2 | 6.1 | 16.8 | 39.8 | 3.0 | ........ |
| Average | **62.2** | **2.5** | **3.4** | **11.2** | **19.3** | **1.4** | **6** |
| Redtop,[1] in bloom: | | | | | | | |
| Minimum | 51.5 | 1.7 | 2.0 | 8.0 | 11.7 | 0.6 | ........ |
| Maximum | 76.2 | 2.9 | 4.3 | 15.7 | 21.9 | 1.1 | ........ |
| Average | **65.3** | **2.3** | **2.8** | **11.0** | **17.7** | **0.9** | **5** |
| Tall oat grass,[2] in bloom: | | | | | | | |
| Minimum | 62.3 | 1.6 | 1.7 | 9.2 | 13.0 | 0.6 | ........ |
| Maximum | 73.5 | 3.0 | 3.3 | 9.7 | 20.7 | 1.5 | ........ |
| Average | **69.5** | **2.0** | **2.4** | **9.4** | **15.8** | **0.9** | **3** |
| Orchard grass, in bloom: | | | | | | | |
| Minimum | 66.9 | 1.6 | 1.9 | 5.8 | 9.9 | 0.7 | ........ |
| Maximum | 77.3 | 2.9 | 4.1 | 11.1 | 16.6 | 1.3 | ........ |
| Average | **73.0** | **2.0** | **2.6** | **8.2** | **13.3** | **0.9** | **4** |
| Meadow fescue, in bloom: | | | | | | | |
| Minimum | 67.6 | 1.6 | 1.8 | 10.2 | 12.5 | 0.7 | ........ |
| Maximum | 73.2 | 2.0 | 2.7 | 11.3 | 15.7 | 1.1 | ........ |
| Average | **69.9** | **1.8** | **2.4** | **10.8** | **14.3** | **0.8** | **4** |
| Italian rye grass, coming into bloom: | | | | | | | |
| Minimum | 69.6 | 2.1 | 2.6 | 5.5 | 11.5 | 1.1 | ........ |
| Maximum | 76.6 | 2.8 | 3.8 | 7.5 | 15.4 | 1.6 | ........ |
| Average | **73.2** | **2.5** | **3.1** | **6.8** | **13.3** | **1.3** | **24** |
| Timothy,[3] at different stages: | | | | | | | |
| Minimum | 47.0 | 1.4 | 1.3 | 5.1 | 10.1 | 0.6 | ........ |
| Maximum | 78.7 | 3.2 | 3.8 | 19.4 | 23.6 | 2.0 | ........ |
| Average | **61.6** | **2.1** | **3.1** | **11.8** | **20.2** | **1.2** | **56** |
| Kentucky blue grass,[4] at different stages: | | | | | | | |
| Minimum | 51.7 | 1.6 | 2.4 | 3.8 | 6.5 | 0.8 | ........ |
| Maximum | 82.5 | 4.8 | 7.2 | 14.8 | 26.6 | 1.9 | ........ |
| Average | **65.1** | **2.8** | **4.1** | **9.1** | **17.6** | **1.3** | **18** |
| Hungarian grass: | | | | | | | |
| Minimum | 62.7 | 1.9 | 2.8 | 7.6 | 9.1 | 0.5 | ........ |
| Maximum | 78.3 | 2.2 | 3.2 | 10.8 | 20.1 | 1.1 | ........ |
| Average | **71.1** | **1.7** | **3.1** | **9.2** | **14.2** | **0.7** | **14** |
| Red clover, at different stages: | | | | | | | |
| Minimum | 47.1 | 0.9 | 1.7 | 1.8 | 3.5 | 0.3 | ........ |
| Maximum | 91.8 | 4.0 | 7.1 | 14.7 | 25.8 | 1.8 | ........ |
| Average | **70.8** | **2.1** | **4.4** | **8.1** | **13.5** | **1.1** | **43** |
| Alsike clover,[5] in bloom: | | | | | | | |
| Minimum | 72.3 | 1.9 | 3.6 | 5.3 | 10.8 | 0.6 | ........ |
| Maximum | 77.3 | 2.1 | 4.2 | 9.4 | 11.5 | 1.2 | ........ |
| Average | **74.8** | **2.0** | **3.9** | **7.4** | **11.0** | **0.9** | **4** |
| Crimson clover: | | | | | | | |
| Minimum | 78.4 | 1.4 | 2.7 | 3.5 | 7.0 | 0.6 | ........ |
| Maximum | 84.6 | 2.0 | 3.5 | 6.3 | 9.7 | 0.8 | ........ |
| Average | **80.9** | **1.7** | **3.1** | **5.2** | **8.4** | **0.7** | **3** |
| Alfalfa,[6] at different stages: | | | | | | | |
| Minimum | 40.3 | 1.8 | 3.5 | 2.5 | 10.8 | 0.6 | ........ |
| Maximum | 82.0 | 5.1 | 7.7 | 14.8 | 11.5 | 1.2 | ........ |
| Average | **71.8** | **2.7** | **4.8** | **7.4** | **12.3** | **1.0** | **23** |
| Serradella, at different stages: | | | | | | | |
| Minimum | 65.6 | 1.8 | 2.1 | 2.0 | 3.9 | 0.4 | ........ |
| Maximum | 84.6 | 5.8 | 3.6 | 7.8 | 17.1 | 1.8 | ........ |
| Average | **79.5** | **3.2** | **2.7** | **5.4** | **8.6** | **0.7** | **9** |
| Cowpea: | | | | | | | |
| Minimum | 72.8 | 1.2 | 1.5 | 1.7 | 1.8 | 0.2 | ........ |
| Maximum | 93.1 | 2.7 | 3.5 | 15.3 | 12.9 | 0.6 | ........ |
| Average | **83.6** | **1.7** | **2.4** | **4.8** | **7.1** | **0.4** | **10** |
| Soy bean: | | | | | | | |
| Minimum | 63.6 | 1.8 | 2.2 | 4.8 | 5.8 | 0.5 | ........ |
| Maximum | 81.5 | 5.1 | 5.9 | 9.7 | 16.0 | 1.6 | ........ |
| Average | **75.1** | **2.6** | **4.0** | **6.7** | **10.6** | **1.0** | **27** |
| Horse bean: Average | **85.1** | **1.4** | **3.0** | **4.3** | **5.7** | **0.5** | **4** |
| Flat pea (*Lathyrus sylvestris*): Average | **66.7** | **2.9** | **8.7** | **7.9** | **12.2** | **1.6** | **2** |
| Rape: | | | | | | | |
| Minimum | 80.8 | 1.2 | 1.8 | 1.2 | 3.6 | 0.4 | ........ |
| Maximum | 91.1 | 3.1 | 4.5 | 3.6 | 9.5 | 1.1 | ........ |
| Average | **85.7** | **2.0** | **2.4** | **2.2** | **7.1** | **0.6** | **10** |

[1] Herd's grass of Pennsylvania.

[2] Meadow oat grass.

[3] Herd's grass of New England and New York.

[4] June grass.

[5] Swedish clover.

[6] Lucern.

*Composition of feeding stuffs*—Continued.

| Feeding stuff. | Water. | Ash. | Protein. | Fiber. | Nitrogen-free extract. | Fat. |
|---|---|---|---|---|---|---|
| SILAGE. | | | | | | |
| **Corn silage:** | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* |
| Minimum | 53.4 | 0.3 | 0.7 | 3.0 | 5.1 | 0.2 |
| Maximum | 87.7 | 3.3 | 3.6 | 10.5 | 24.2 | 2.0 |
| Average | **77.3** | **1.4** | **1.9** | **5.9** | **12.6** | **0.9** |
| Recent analyses; corn more mature: | | | | | | |
| Minimum | 53.4 | 0.9 | 1.0 | 3.6 | 5.9 | 0.4 |
| Maximum | 87.6 | 2.7 | 3.1 | 9.9 | 30.6 | 2.0 |
| Average | **74.4** | **1.5** | **2.2** | **5.8** | **15.0** | **1.1** |
| **Sorghum silage:** | | | | | | |
| Minimum | 71.9 | 0.8 | 0.6 | 5.9 | 13.8 | 0.1 |
| Maximum | 78.0 | 1.2 | 0.9 | 6.8 | 19.0 | 0.5 |
| Average | **76.1** | **1.1** | **0.8** | **6.4** | **15.3** | **0.3** |
| **Red clover silage:** | | | | | | |
| Minimum | 61.4 | 1.9 | 3.0 | 5.1 | 8.1 | 0.9 |
| Maximum | 78.6 | 3.0 | 5.9 | 13.9 | 14.3 | 1.6 |
| Average | **72.0** | **2.6** | **4.2** | **8.4** | **11.6** | **1.2** |
| **Soy bean silage: Average** | **74.2** | **2.8** | **4.1** | **9.7** | **6.9** | **2.2** |
| **Cowpea vine silage: Average** | **79.3** | **2.9** | **2.7** | **6.0** | **7.6** | **1.5** |
| **Field pea vine silage: Average** | **50.1** | **3.5** | **5.9** | **13.0** | **26.0** | **1.6** |
| **Silage of mixture of cowpea vines and soy bean vines: Average** | **69.8** | **4.5** | **3.8** | **9.5** | **11.1** | **1.3** |
| HAY AND DRY COARSE FODDER. | | | | | | |
| Corn fodder,[1] field cured: | | | | | | |
| Minimum | 22.9 | 1.5 | 2.7 | 7.5 | 20.6 | 0.6 |
| Maximum | 60.2 | 5.5 | 6.9 | 24.7 | 47.8 | 2.5 |
| Average | **42.2** | **2.7** | **4.5** | **14.3** | **34.7** | **1.6** |
| Corn leaves, field cured: | | | | | | |
| Minimum | 14.8 | 4.3 | 4.5 | 17.4 | 27.3 | 0.8 |
| Maximum | 44.0 | 7.4 | 8.3 | 27.4 | 41.4 | 2.2 |
| Average | **30.0** | **5.5** | **6.0** | **21.4** | **35.7** | **1.4** |
| Corn husks, field cured: | | | | | | |
| Minimum | 26.7 | 0.6 | 1.3 | 6.8 | 14.3 | 0.5 |
| Maximum | 76.6 | 2.3 | 3.2 | 23.6 | 43.6 | 1.0 |
| Average | **50.9** | **1.8** | **2.5** | **15.8** | **28.3** | **0.7** |
| Cornstalks, field cured: | | | | | | |
| Minimum | 51.3 | 0.6 | 1.2 | 6.9 | 11.2 | 0.3 |
| Maximum | 78.5 | 2.0 | 3.0 | 16.8 | 26.0 | 1.0 |
| Average | **68.4** | **1.2** | **1.9** | **11.0** | **17.0** | **0.5** |
| Corn stover,[2] field cured: | | | | | | |
| Minimum | 15.4 | 1.7 | 1.8 | 14.1 | 23.3 | 0.7 |
| Maximum | 57.4 | 7.0 | 8.3 | 32.2 | 53.3 | 2.2 |
| Average | **40.5** | **3.4** | **3.8** | **19.7** | **31.5** | **1.1** |
| Kafir corn stover, field cured: | | | | | | |
| Average | **19.2** | **8.0** | **4.8** | **26.8** | **39.6** | **1.6** |
| Hay from: | | | | | | |
| Barley— | | | | | | |
| Minimum | 6.4 | 4.2 | 8.0 | 21.0 | 44.9 | 2.4 |
| Maximum | 15.0 | 7.1 | 11.1 | 26.1 | 51.8 | 2.8 |
| Average | **10.6** | **5.3** | **9.3** | **23.6** | **48.7** | **2.5** |
| Oats— | | | | | | |
| Minimum | 9.5 | 4.6 | 5.2 | 23.1 | 31.9 | 1.8 |
| Maximum | 26.5 | 9.4 | 9.5 | 30.9 | 48.5 | 3.3 |
| Average | **16.0** | **6.1** | **7.4** | **27.2** | **40.6** | **2.7** |
| Redtop,[3] cut at different stages— | | | | | | |
| Minimum | 6.8 | 3.8 | 5.9 | 24.0 | 44.8 | 1.4 |
| Maximum | 11.6 | 7.0 | 10.4 | 31.8 | 50.4 | 3.2 |
| Average | **8.9** | **5.2** | **7.9** | **28.6** | **47.5** | **1.9** |
| Redtop, cut in bloom— | | | | | | |
| Minimum | 6.8 | 4.8 | 7.8 | 24.0 | 46.8 | 1.5 |
| Maximum | 11.6 | 6.5 | 10.4 | 31.8 | 47.8 | 2.3 |
| Average | **8.7** | **4.9** | **8.0** | **29.9** | **46.4** | **2.1** |
| Orchard grass— | | | | | | |
| Minimum | 6.5 | 5.0 | 6.6 | 28.9 | 32.9 | 1.7 |
| Maximum | 13.6 | 7.9 | 10.4 | 38.3 | 48.6 | 3.3 |
| Average | **9.9** | **6.0** | **8.1** | **32.4** | **41.0** | **2.6** |
| Timothy,[4] all analyses— | | | | | | |
| Minimum | 6.1 | 2.5 | 3.8 | 22.2 | 34.3 | 1.0 |
| Maximum | 28.9 | 6.3 | 9.8 | 38.5 | 58.5 | 4.0 |
| Average | **13.2** | **4.4** | **5.9** | **29.0** | **45.0** | **2.5** |
| Timothy, cut in full bloom— | | | | | | |
| Minimum | 7.0 | 2.5 | 5.0 | 22.2 | 34.4 | 2.0 |
| Maximum | 28.9 | 6.0 | 7.5 | 37.1 | 48.5 | 4.0 |
| Average | **15.0** | **4.5** | **6.0** | **29.6** | **41.9** | **3.0** |

[1] Entire plant.

[2] What is left after the ears are harvested.

[3] Herd's grass of Pennsylvania.

[4] Herd's grass of New England and New

*Composition of feeding stuffs*—Continued.

| Feeding stuff. | Water. | Ash. | Protein. | Fiber. | Nitrogen-free extract. | Fat. | Number of analyses. |
|---|---|---|---|---|---|---|---|
| Y AND DRY COARSE FODDER—cont'd. | | | | | | | |
| from—Continued. | | | | | | | |
| Timothy cut soon after bloom— | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | |
| Minimum | 7.8 | 3.5 | 4.6 | 25.7 | 37.0 | 1.7 | ........ |
| Maximum | 21.6 | 5.4 | 8.1 | 33.4 | 51.0 | 3.6 | ........ |
| Average | **14.2** | **4.4** | **5.7** | **28.1** | **44.6** | **3.0** | 11 |
| Timothy cut when nearly ripe— | | | | | | | |
| Minimum | 7.0 | 2.7 | 4.3 | 24.8 | 38.0 | 1.0 | ........ |
| Maximum | 22.7 | 5.1 | 6.0 | 38.5 | 49.1 | 2.8 | ........ |
| Average | **14.1** | **3.9** | **5.0** | **31.1** | **43.7** | **2.2** | 12 |
| Kentucky blue grass— | | | | | | | |
| Minimum | 14.3 | 4.5 | 5.3 | 17.7 | 31.8 | 2.0 | ........ |
| Maximum | 32.8 | 7.8 | 12.9 | 26.8 | 51.1 | 4.2 | ........ |
| Average | **21.2** | **6.3** | **7.8** | **23.0** | **37.8** | **3.9** | 10 |
| Cut when seed was in milk— | | | | | | | |
| Minimum | 22.5 | 5.6 | 6.0 | 23.9 | 33.2 | 3.4 | ........ |
| Maximum | 26.5 | 7.6 | 6.6 | 24.9 | 35.4 | 4.1 | ........ |
| Average | **24.4** | **7.0** | **6.3** | **24.5** | **34.2** | **3.6** | 4 |
| Cut when seed was ripe— | | | | | | | |
| Minimum | 23.7 | 5.1 | 5.3 | 20.4 | 33.6 | 2.8 | ........ |
| Maximum | 32.8 | 7.8 | 6.0 | 25.7 | 33.7 | 3.2 | ........ |
| Average | **27.8** | **6.4** | **5.8** | **23.8** | **33.2** | **3.0** | 4 |
| Hungarian grass— | | | | | | | |
| Minimum | 4.9 | 5.0 | 4.7 | 23.6 | 44.4 | 1.5 | ........ |
| Maximum | 9.5 | 7.5 | 12.3 | 36.3 | 53.0 | 3.5 | ........ |
| Average | **7.7** | **6.0** | **7.5** | **27.7** | **49.0** | **2.1** | 13 |
| Meadow fescue— | | | | | | | |
| Minimum | 7.4 | 5.5 | 4.5 | 20.8 | 28.5 | 1.6 | ........ |
| Maximum | 32.5 | 7.8 | 11.8 | 31.9 | 45.5 | 3.5 | ........ |
| Average | **20.0** | **6.8** | **7.0** | **25.9** | **38.4** | **2.7** | 9 |
| Italian rye grass— | | | | | | | |
| Minimum | 7.4 | 6.1 | 5.7 | 28.4 | 39.6 | 1.3 | ........ |
| Maximum | 9.3 | 7.9 | 8.8 | 33.9 | 48.9 | 1.9 | ........ |
| Average | **8.5** | **6.9** | **7.5** | **30.5** | **45.0** | **1.7** | 4 |
| Mixed grasses— | | | | | | | |
| Minimum | 6.5 | 2.1 | 4.8 | 21.0 | 33.4 | 1.3 | ........ |
| Maximum | 33.4 | 6.9 | 12.1 | 38.4 | 50.8 | 4.9 | ........ |
| Average | **15.3** | **5.5** | **7.4** | **27.2** | **42.1** | **2.5** | 126 |
| Rowen (mixed)[1]— | | | | | | | |
| Minimum | 8.2 | 5.1 | 9.6 | 20.1 | 33.6 | 2.2 | ........ |
| Maximum | 24.4 | 7.2 | 14.8 | 20.0 | 44.3 | 4.5 | ........ |
| Average | **16.6** | **6.8** | **11.6** | **22.5** | **39.4** | **3.1** | 23 |
| Mixed grasses and clovers— | | | | | | | |
| Minimum | 8.2 | 3.9 | 5.5 | 19.7 | 31.8 | 1.5 | ........ |
| Maximum | 15.9 | 9.6 | 14.4 | 35.1 | 48.9 | 3.1 | ........ |
| Average | **12.9** | **5.5** | **10.1** | **27.6** | **41.3** | **2.6** | 17 |
| Swamp hay— | | | | | | | |
| Minimum | 7.8 | 3.3 | 5.0 | 19.4 | 39.9 | 0.8 | ........ |
| Maximum | 17.9 | 12.1 | 8.8 | 31.6 | 51.7 | 3.6 | ........ |
| Average | **11.6** | **6.7** | **7.2** | **26.6** | **45.9** | **2.0** | 8 |
| Salt marsh hay— | | | | | | | |
| Minimum | 7.8 | 5.4 | 4.0 | 25.1 | 34.1 | 1.6 | ........ |
| Maximum | 18.6 | 11.8 | 7.8 | 33.8 | 54.3 | 3.1 | ........ |
| Average | **10.4** | **7.7** | **5.5** | **30.0** | **44.1** | **2.4** | 10 |
| Red clover— | | | | | | | |
| Minimum | 6.0 | 3.9 | 10.0 | 15.6 | 27.3 | 1.5 | ........ |
| Maximum | 31.3 | 8.3 | 20.2 | 35.7 | 52.2 | 5.9 | ........ |
| Average | **15.3** | **6.2** | **12.3** | **24.8** | **38.1** | **3.3** | 38 |
| Red clover in bloom— | | | | | | | |
| Minimum | 6.0 | 5.6 | 10.8 | 17.9 | 27.3 | 2.5 | ........ |
| Maximum | 31.3 | 8.3 | 15.4 | 28.1 | 41.3 | 5.9 | ........ |
| Average | **20.8** | **6.6** | **12.4** | **21.9** | **33.8** | **4.5** | 6 |
| Alsike clover— | | | | | | | |
| Minimum | 5.3 | 6.1 | 9.2 | 19.7 | 35.6 | 1.6 | ........ |
| Maximum | 13.9 | 12.2 | 16.1 | 29.5 | 45.9 | 4.2 | ........ |
| Average | **9.7** | **8.3** | **12.8** | **25.6** | **40.7** | **2.9** | 9 |
| White clover— | | | | | | | |
| Minimum | 6.1 | 4.5 | 13.9 | 20.3 | 33.4 | 1.7 | ........ |
| Maximum | 13.5 | 13.8 | 20.0 | 30.3 | 47.3 | 5.8 | ........ |
| Average | **9.7** | **8.3** | **15.7** | **24.1** | **39.3** | **2.9** | 7 |
| Crimson clover— | | | | | | | |
| Minimum | 5.9 | 7.4 | 13.6 | 20.1 | 29.3 | 1.5 | ........ |
| Maximum | 13.4 | 13.0 | 16.1 | 34.9 | 42.6 | 4.8 | ........ |
| Average | **9.6** | **8.6** | **15.2** | **27.2** | **36.6** | **2.8** | 7 |
| Japan clover— | | | | | | | |
| Average | **11.0** | **8.5** | **13.8** | **24.0** | **39.0** | **3.7** | 2 |
| Vetch— | | | | | | | |
| Minimum | 8.3 | 7.1 | 13.1 | 19.7 | 26.5 | 1.6 | ........ |
| Maximum | 15.8 | 11.6 | 23.1 | 28.1 | 40.2 | 3.0 | ........ |
| Average | **11.3** | **7.9** | **17.0** | **25.4** | **36.1** | **2.3** | 5 |

[1] Second cut.

*Composition of feeding stuffs*—Continued.

| Feeding stuff. | Water. | Ash. | Protein. | Fiber. | Nitrogen-free extract. | Fat. |
|---|---|---|---|---|---|---|
| HAY AND DRY COARSE FODDER—cont'd. | | | | | | |
| Hay from—Continued. | | | | | | |
| Serradella— | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* |
| Minimum | 7.2 | 5.4 | 13.9 | 19.4 | 40.5 | 2.2 |
| Maximum | 11.7 | 10.3 | 16.6 | 22.9 | 46.0 | 2.9 |
| Average | **9.2** | **7.2** | **15.2** | **21.6** | **44.2** | **2.6** |
| Alfalfa[1]— | | | | | | |
| Minimum | 4.6 | 3.1 | 10.2 | 14.0 | 35.1 | 1.1 |
| Maximum | 16.0 | 10.4 | 20.3 | 33.0 | 53.6 | 3.8 |
| Average | **8.4** | **7.4** | **14.3** | **25.0** | **42.7** | **2.2** |
| Cowpea— | | | | | | |
| Minimum | 7.6 | 3.2 | 13.6 | 16.4 | 39.4 | 1.1 |
| Maximum | 14.0 | 10.2 | 20.3 | 26.0 | 49.5 | 3.7 |
| Average | **10.7** | **7.5** | **16.6** | **20.1** | **42.2** | **2.9** |
| Soy bean— | | | | | | |
| Minimum | 6.1 | 4.8 | 14.0 | 17.3 | 31.8 | 2.4 |
| Maximum | 20.1 | 8.9 | 18.1 | 32.3 | 41.0 | 7.5 |
| Average | **11.3** | **7.2** | **15.4** | **22.3** | **38.6** | **5.2** |
| Flat pea (*Lathyrus sylvestris*)— | | | | | | |
| Minimum | 6.3 | 6.5 | 17.6 | 18.5 | 27.7 | 1.6 |
| Maximum | 10.0 | 8.6 | 27.9 | 32.7 | 34.0 | 4.6 |
| Average | **8.4** | **7.9** | **22.9** | **26.2** | **31.4** | **3.2** |
| Peanut vines (without nuts)— | | | | | | |
| Minimum | 6.3 | 7.3 | 9.1 | 18.3 | 33.1 | 1.7 |
| Maximum | 7.8 | 15.7 | 11.7 | 33.3 | 50.4 | 5.8 |
| Average | **7.6** | **10.8** | **10.7** | **23.6** | **42.7** | **4.6** |
| Soy bean straw: | | | | | | |
| Minimum | 5.7 | 3.9 | 4.0 | 34.0 | 35.3 | 0.8 |
| Maximum | 14.0 | 4.9 | 4.9 | 49.6 | 43.3 | 3.2 |
| Average | **10.1** | **5.8** | **4.6** | **40.4** | **37.4** | **1.7** |
| Horse bean straw: Average | **9.2** | **8.7** | **8.8** | **37.6** | **34.3** | **1.4** |
| Wheat straw: | | | | | | |
| Minimum | 6.5 | 3.0 | 2.9 | 34.3 | 31.0 | 0.8 |
| Maximum | 17.9 | 7.0 | 5.0 | 42.7 | 50.6 | 1.8 |
| Average | **9.6** | **4.2** | **3.4** | **38.1** | **43.4** | **1.3** |
| Rye straw: | | | | | | |
| Minimum | 6.3 | 2.8 | 2.2 | 32.7 | 41.0 | 1.0 |
| Maximum | 9.7 | 3.4 | 3.6 | 43.3 | 52.9 | 1.6 |
| Average | **7.1** | **3.2** | **3.0** | **38.9** | **46.6** | **1.2** |
| Oat straw: | | | | | | |
| Minimum | 6.5 | 3.7 | 2.7 | 31.8 | 33.5 | 1.7 |
| Maximum | 11.4 | 6.7 | 6.9 | 45.1 | 46.6 | 3.2 |
| Average | **9.2** | **5.1** | **4.0** | **37.0** | **42.4** | **2.3** |
| Buckwheat straw: | | | | | | |
| Minimum | 9.0 | 4.9 | 3.3 | 37.2 | 32.1 | 0.7 |
| Maximum | 10.4 | 6.5 | 7.8 | 46.8 | 38.9 | 1.7 |
| Average | **9.9** | **5.5** | **5.2** | **43.0** | **35.1** | **1.3** |
| ROOTS AND TUBERS. | | | | | | |

*Composition of feeding stuffs*—Continued.

| Feeding stuff. | Water. | Ash. | Protein. | Fiber. | Nitrogen-free extract. | Fat. | Number of analyses. |
|---|---|---|---|---|---|---|---|
| ROOTS AND TUBERS—continued. | | | | | | | |
| Carrots: | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | |
| Minimum | 86.5 | 1.6 | 0.8 | 0.9 | 5.1 | 0.2 | ........ |
| Maximum | 91.1 | 1.3 | 2.0 | 2.3 | 10.4 | 0.7 | ........ |
| **Average** | **88.6** | **1.0** | **1.1** | **1.3** | **7.6** | **0.4** | 8 |
| Artichokes: | | | | | | | |
| Minimum | 75.7 | 1.2 | 2.0 | 0.7 | 15.9 | 0.1 | ........ |
| Maximum | 79.7 | 3.7 | 2.6 | 1.1 | 18.1 | 0.2 | ........ |
| **Average** | **78.0** | **1.8** | **2.4** | **0.9** | **16.8** | **0.1** | 7 |
| GRAINS AND OTHER SEEDS. | | | | | | | |
| Corn, kernel: | | | | | | | |
| Dent, all analyses— | | | | | | | |
| Minimum | 6.2 | 1.0 | 7.5 | 0.9 | 65.9 | 3.1 | ........ |
| Maximum | 19.4 | 2.6 | 11.8 | 4.8 | 75.7 | 7.5 | ........ |
| **Average** | **10.6** | **1.5** | **10.3** | **2.2** | **70.4** | **5.0** | 80 |
| Flint, all analyses— | | | | | | | |
| Minimum | 4.5 | 1.0 | 7.0 | 0.7 | 65.0 | 3.4 | ........ |
| Maximum | 19.6 | 1.9 | 13.7 | 2.9 | 76.7 | 7.1 | ........ |
| **Average** | **11.3** | **1.4** | **10.5** | **1.7** | **70.1** | **5.0** | 68 |
| All varieties and analyses— | | | | | | | |
| Minimum | 4.5 | 1.0 | 7.0 | 0.7 | 61.8 | 3.1 | ........ |
| Maximum | 20.7 | 2.6 | 15.3 | 5.2 | 76.7 | 9.3 | ........ |
| **Average** | **10.9** | **1.5** | **10.5** | **2.1** | **69.6** | **5.4** | 208 |
| Kafir corn, kernel: | | | | | | | |
| **Average** | **12.5** | **1.8** | **10.9** | **1.9** | **70.5** | **2.9** | 6 |
| Sorghum seed: | | | | | | | |
| Minimum | 9.3 | 1.4 | 7.7 | 1.5 | 59.0 | 2.1 | ........ |
| Maximum | 16.8 | 4.3 | 11.3 | 8.7 | 73.6 | 4.6 | ........ |
| **Average** | **12.8** | **2.1** | **9.1** | **2.6** | **69.8** | **3.6** | 10 |
| Barley: | | | | | | | |
| Minimum | 7.2 | 1.8 | 8.6 | 1.3 | 66.7 | 1.5 | ........ |
| Maximum | 12.6 | 3.2 | 15.7 | 4.2 | 73.9 | 3.2 | ........ |
| **Average** | **10.9** | **2.4** | **12.4** | **2.7** | **69.8** | **1.8** | 10 |
| Oats: | | | | | | | |
| Minimum | 8.9 | 2.0 | 8.0 | 1.5 | 53.5 | 3.4 | ........ |
| Maximum | 13.5 | 4.0 | 14.4 | 12.9 | 66.9 | 5.8 | ........ |
| **Average** | **11.0** | **3.0** | **11.8** | **9.5** | **59.7** | **5.0** | 30 |
| Rye: | | | | | | | |
| Minimum | 8.7 | 1.8 | 9.5 | 1.4 | 71.2 | 1.4 | ........ |
| Maximum | 13.2 | 1.9 | 12.1 | 2.1 | 73.9 | 2.1 | ........ |
| **Average** | **11.6** | **1.9** | **10.6** | **1.7** | **72.5** | **1.7** | 6 |
| Wheat, spring varieties: | | | | | | | |
| Minimum | 8.1 | 1.5 | 8.4 | 1.3 | 66.1 | 1.8 | ........ |
| Maximum | 13.4 | 2.6 | 15.4 | 2.3 | 71.9 | 2.6 | ........ |
| **Average** | **10.4** | **1.9** | **12.5** | **1.8** | **71.2** | **2.2** | 13 |
| Wheat, winter varieties, all analyses: | | | | | | | |
| Minimum | 7.1 | 0.8 | 8.1 | 0.4 | 66.7 | 1.3 | ........ |
| Maximum | 14.0 | 3.6 | 16.6 | 2.9 | 77.7 | 3.9 | ........ |
| **Average** | **10.5** | **1.8** | **11.8** | **1.8** | **72.0** | **2.1** | 262 |
| Wheat, all varieties: | | | | | | | |
| Minimum | 7.1 | 0.8 | 8.1 | 0.4 | 64.8 | 1.3 | ........ |
| Maximum | 14.0 | 3.6 | 17.2 | 3.1 | 77.7 | 3.9 | ........ |
| **Average** | **10.5** | **1.8** | **11.9** | **1.8** | **71.9** | **2.1** | 310 |
| Rice: | | | | | | | |
| Minimum | 11.4 | 0.3 | 5.9 | 0.1 | 77.5 | 0.3 | ........ |
| Maximum | 14.0 | 0.5 | 8.6 | 0.4 | 80.6 | 0.6 | ........ |
| **Average** | **12.4** | **0.4** | **7.4** | **0.2** | **79.2** | **0.4** | 10 |
| Buckwheat: | | | | | | | |
| Minimum | 10.9 | 1.6 | 8.6 | 7.8 | 62.6 | 2.2 | ........ |
| Maximum | 14.8 | 2.3 | 11.0 | 9.4 | 65.4 | 2.4 | ........ |
| **Average** | **12.6** | **2.0** | **10.0** | **8.7** | **64.5** | **2.2** | 8 |
| Sunflower seed (whole): | | | | | | | |
| Minimum | 8.5 | 2.1 | 15.8 | 29.5 | 22.0 | 20.9 | ........ |
| Maximum | 8.8 | 3.2 | 16.7 | 30.3 | 20.7 | 21.5 | ........ |
| **Average** | **8.6** | **2.6** | **16.8** | **29.9** | **21.4** | **21.2** | 2 |
| Cotton seed, whole (with hulls): | | | | | | | |
| Minimum | 5.8 | 2.9 | 14.5 | 10.9 | 17.3 | 15.3 | ........ |
| Maximum | 17.5 | 5.0 | 21.7 | 28.7 | 36.4 | 22.5 | ........ |
| **Average** | **9.1** | **4.0** | **19.6** | **18.9** | **28.3** | **20.1** | 11 |
| Peanut kernel (without hulls): | | | | | | | |
| Minimum | 4.9 | 1.9 | 23.2 | 2.0 | 12.7 | 35.0 | ........ |
| Maximum | 13.2 | 3.8 | 31.5 | 18.4 | 19.1 | 47.4 | ........ |
| **Average** | **7.5** | **2.4** | **27.9** | **7.0** | **15.6** | **39.6** | 7 |
| Soy bean: | | | | | | | |
| Minimum | 2.8 | 3.1 | 26.3 | 2.2 | 23.3 | 12.3 | ........ |
| Maximum | 19.3 | 12.4 | 41.8 | 8.3 | 35.3 | [illegible] | |
| **Average** | **8.7** | **5.4** | **36.3** | **3.9** | **27.7** | | |

*Composition of feeding stuffs*—Continued.

| Feeding stuff. | Water. | Ash. | Protein. | Fiber. | Nitrogen-free extract. | Fat. | Number of analyses. |
|---|---|---|---|---|---|---|---|
| GRAINS AND OTHER SEEDS—continued. | | | | | | | |
| Cowpea: | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | |
| Minimum | 9.6 | 2.9 | 19.3 | 2.5 | 50.5 | 1.3 | ........ |
| Maximum | 20.9 | 4.0 | 26.4 | 5.0 | 62.0 | 2.7 | ........ |
| Average | **11.9** | **3.4** | **23.5** | **3.8** | **55.7** | **1.7** | 17 |
| MILL PRODUCTS. | | | | | | | |
| Corn meal: | | | | | | | |
| Minimum | 8.0 | 0.9 | 7.1 | 0.5 | 60.4 | 2.0 | ........ |
| Maximum | 27.4 | 4.1 | 13.9 | 3.1 | 74.0 | 5.1 | ........ |
| Average | **15.0** | **1.4** | **9.2** | **1.9** | **68.7** | **3.8** | 77 |
| Corn and cob meal: | | | | | | | |
| Minimum | 9.5 | 1.2 | 5.8 | 4.7 | 56.8 | 2.5 | ........ |
| Maximum | 26.3 | 1.9 | 12.2 | 9.4 | 69.7 | 4.7 | ........ |
| Average | **15.1** | **1.5** | **8.5** | **6.6** | **64.8** | **3.5** | 7 |
| Barley meal: | | | | | | | |
| Minimum | 9.9 | 1.6 | 9.8 | 5.9 | 63.5 | 1.5 | ........ |
| Maximum | 13.6 | 3.8 | 12.7 | 7.0 | 68.0 | 3.2 | ........ |
| Average | **11.9** | **2.6** | **10.5** | **6.5** | **66.3** | **2.2** | 3 |
| Rye flour: | | | | | | | |
| Minimum | 12.4 | 0.6 | 6.0 | 0.4 | 77.6 | 0.8 | ........ |
| Maximum | 13.6 | 0.8 | 6.9 | 0.5 | 79.1 | 0.9 | ........ |
| Average | **13.1** | **0.7** | **6.7** | **0.4** | **78.3** | **0.8** | 4 |
| Pea meal: | | | | | | | |
| Minimum | 8.9 | 2.6 | 19.1 | 11.1 | 50.2 | 0.9 | ........ |
| Maximum | 12.1 | 2.7 | 21.4 | 17.7 | 52.0 | 1.5 | ........ |
| Average | **10.5** | **2.6** | **20.2** | **14.4** | **51.1** | **1.2** | 2 |
| Soy-bean meal | **10.2** | **5.0** | **35.9** | **3.4** | **28.0** | **17.5** | 4 |
| Ground corn and oats, equal parts: | | | | | | | |
| Minimum | 10.7 | 1.9 | 8.4 | ........ | [1]70.4 | 4.0 | ........ |
| Maximum | 13.1 | 2.7 | 10.4 | ........ | [1]73.7 | 5.0 | ........ |
| Average | **11.9** | **2.2** | **9.6** | ........ | **[1]72.0** | **4.4** | 6 |
| WASTE PRODUCTS. | | | | | | | |
| Corncob: | | | | | | | |
| Minimum | 7.2 | 0.7 | 1.2 | 18.2 | 43.8 | 0.1 | ........ |
| Maximum | 24.8 | 2.7 | 3.7 | 38.3 | 66.7 | 0.9 | ........ |
| Average | **10.7** | **1.4** | **2.4** | **30.1** | **54.9** | **0.5** | 18 |
| Hominy chop: | | | | | | | |
| Minimum | 8.1 | 1.9 | 7.9 | 2.5 | 61.0 | 4.5 | ........ |
| Maximum | 13.5 | 3.1 | 11.2 | 6.7 | 71.1 | 11.2 | ........ |
| Average | **11.1** | **2.5** | **9.8** | **3.8** | **64.5** | **8.3** | 12 |
| Corn bran: | | | | | | | |
| Minimum | 7.1 | 0.8 | 7.7 | 7.8 | 57.2 | 4.0 | ........ |
| Maximum | 12.3 | 2.4 | 11.8 | 14.3 | 68.9 | 8.5 | ........ |
| Average | **8.7** | **1.5** | **9.8** | **11.2** | **62.6** | **6.2** | 6 |
| Corn germ: | | | | | | | |
| Minimum | 9.4 | 1.9 | 9.7 | 1.9 | 61.9 | 5.2 | ........ |
| Maximum | 13.0 | 7.4 | 9.9 | 5.8 | 67.4 | 11.2 | ........ |
| Average | **10.7** | **4.0** | **9.8** | **4.1** | **64.0** | **7.4** | 3 |
| Corn-germ meal: | | | | | | | |
| Minimum | 6.5 | 0.8 | 10.0 | 7.8 | 57.4 | 4.3 | ........ |
| Maximum | 9.9 | 2.6 | 14.0 | 13.0 | 67.0 | 11.2 | ........ |
| Average | **8.1** | **1.3** | **11.1** | **9.9** | **62.5** | **7.1** | 6 |
| Gluten meal: | | | | | | | |
| Miscellaneous— | | | | | | | |
| Minimum | 4.5 | 0.5 | 10.3 | 0.3 | 32.4 | 1.7 | ........ |
| Maximum | 12.3 | 2.0 | 49.1 | 9.3 | 62.7 | 20.0 | ........ |
| Average | **8.6** | **0.8** | **30.0** | **2.6** | **49.2** | **8.8** | 67 |
| Buffalo, average | **8.2** | **0.9** | **24.5** | **6.1** | **47.8** | **12.5** | 7 |
| Chicago— | | | | | | | |
| Minimum | 5.5 | 0.6 | 29.2 | 1.1 | 37.0 | 1.0 | ........ |
| Maximum | 17.2 | 2.3 | 43.1 | 6.3 | 52.6 | 9.6 | ........ |
| Average | **9.5** | **1.2** | **37.6** | **2.3** | **44.4** | **5.0** | 42 |
| Hammond, average | **8.1** | **1.0** | **28.3** | **1.1** | **50.8** | **10.7** | 5 |
| King— | | | | | | | |
| Minimum | 3.0 | 0.4 | 26.3 | 1.2 | 33.2 | 2.8 | ........ |
| Maximum | 9.5 | 1.9 | 37.2 | 2.4 | 55.0 | 19.8 | ........ |
| Average | **7.2** | **1.4** | **34.2** | **1.7** | **39.0** | **16.5** | 14 |
| Cream gluten: | | | | | | | |
| Minimum | 7.7 | 0.6 | 34.1 | 1.2 | 35.0 | 13.6 | ........ |
| Maximum | 9.0 | 0.8 | 38.2 | 1.3 | 41.1 | 15.8 | ........ |
| Average | **8.1** | **0.7** | **36.1** | **1.3** | **39.0** | **14.8** | 3 |
| Recent analyses— | | | | | | | |
| Minimum | 8.8 | 0.5 | 32.1 | 1.3 | 47.7 | 1.7 | ........ |
| Maximum | 11.2 | 1.0 | 35.9 | 2.5 | 52.3 | 3.8 | ........ |
| Average | **9.6** | **0.9** | **34.6** | **1.9** | **50.4** | **2.6** | 7 |

[1] Including fiber.

*Composition of feeding stuffs*—Continued.

| Feeding stuff. | Water. | Ash. | Protein. | Fiber. | Nitrogen-free extract. | Fat. | Number of analyses. |
|---|---|---|---|---|---|---|---|
| WASTE PRODUCTS—continued. | | | | | | | |
| Gluten feed: | | | | | | | |
| Miscellaneous— | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | |
| Minimum | 4.4 | 0.6 | 14.8 | 1.3 | 44.5 | 3.0 | ........ |
| Maximum | 12.5 | 3.4 | 28.3 | 11.1 | 61.8 | 15.0 | ........ |
| Average | **7.8** | **1.1** | **23.4** | **6.2** | **53.2** | **8.3** | **42** |
| Recent analyses— | | | | | | | |
| Minimum | 5.4 | 0.6 | 14.8 | 1.3 | 48.5 | 3.0 | ........ |
| Maximum | 10.4 | 3.4 | 28.3 | 11.1 | 60.6 | 11.5 | ........ |
| Average | **8.1** | **1.3** | **23.2** | **6.4** | **54.7** | **6.3** | **20** |
| Buffalo— | | | | | | | |
| Minimum | 7.4 | 0.8 | 19.5 | 2.5 | 44.6 | 2.3 | ........ |
| Maximum | 10.5 | 3.7 | 28.6 | 9.6 | 59.5 | 14.3 | ........ |
| Average | **8.6** | **1.8** | **24.6** | **6.7** | **50.0** | **8.3** | **52** |
| Recent analyses— | | | | | | | |
| Minimum | 7.6 | 0.8 | 21.3 | 2.5 | 49.3 | 2.3 | ........ |
| Maximum | 10.3 | 4.1 | 28.6 | 7.9 | 59.5 | 4.7 | ........ |
| Average | **9.0** | **2.7** | **26.6** | **6.3** | **52.0** | **3.4** | **22** |
| Davenport— | | | | | | | |
| Minimum | 7.6 | 0.9 | 22.9 | 5.5 | 44.6 | 2.5 | ........ |
| Maximum | 10.1 | 1.7 | 34.9 | 7.5 | 56.7 | 6.4 | ........ |
| Average | **8.6** | **1.3** | **26.3** | **6.6** | **52.9** | **4.3** | **6** |
| Glen Cove— | | | | | | | |
| Minimum | 8.2 | 0.4 | 27.1 | 3.8 | 51.9 | 2.9 | ........ |
| Maximum | 9.6 | 0.7 | 29.7 | 4.5 | 56.0 | 4.1 | ........ |
| Average | **8.9** | **0.6** | **28.8** | **4.2** | **53.8** | **3.7** | **4** |
| Pope's | **14.0** | **0.6** | **33.3** | **1.6** | **36.5** | **14.1** | **1** |
| Rockford (Diamond)— | | | | | | | |
| Minimum | 7.2 | 0.6 | 20.0 | 5.8 | 49.3 | 3.2 | ........ |
| Maximum | 9.9 | 7.9 | 30.1 | 8.5 | 59.8 | 10.2 | ........ |
| Average | **8.7** | **1.4** | **23.7** | **6.8** | **54.9** | **4.5** | **13** |
| Waukegan— | | | | | | | |
| Minimum | 6.2 | 1.0 | 24.3 | 5.9 | 50.9 | 3.5 | ........ |
| Maximum | 9.1 | 1.2 | 27.7 | 7.5 | 56.3 | 4.6 | ........ |
| Average | **8.3** | **1.1** | **26.5** | **6.9** | **53.2** | **4.0** | **5** |
| Chicago maize feed: | | | | | | | |
| Minimum | 8.5 | 0.7 | 19.3 | 6.7 | 48.7 | 5.6 | ........ |
| Maximum | 9.7 | 1.4 | 26.9 | 8.7 | 56.1 | 8.3 | ........ |
| Average | **9.1** | **1.0** | **23.6** | **7.4** | **51.7** | **7.2** | **5** |
| Glucose feed and glucose refuse: Average | **6.5** | **1.1** | **20.7** | **4.5** | **56.8** | **10.4** | **2** |
| Dried starch feed and sugar feed: | | | | | | | |
| Minimum | 9.2 | 0.6 | 17.1 | 3.1 | 49.2 | 7.3 | ........ |
| Maximum | 11.7 | 1.2 | 22.1 | 5.6 | 59.6 | 11.1 | ........ |
| Average | **10.9** | **0.9** | **19.7** | **4.7** | **54.8** | **9.0** | **4** |
| Starch feed, wet: | | | | | | | |
| Minimum | 62.3 | 0.1 | 3.6 | 1.6 | 18.7 | 1.3 | ........ |
| Maximum | 72.2 | 0.6 | 9.6 | 4.4 | 28.9 | 4.4 | ........ |
| Average | **65.4** | **0.3** | **6.1** | **3.1** | **22.0** | **3.1** | **12** |
| Oat feed: | | | | | | | |
| Minimum | 6.4 | 3.2 | 12.6 | 3.7 | 56.2 | 6.1 | ........ |
| Maximum | 9.2 | 4.2 | 20.0 | 12.5 | 63.7 | 7.8 | ........ |
| Average | **7.7** | **3.7** | **16.0** | **6.1** | **59.4** | **7.1** | **4** |
| Barley screenings: | | | | | | | |
| Minimum | 12.0 | 3.5 | 12.1 | 7.0 | 61.6 | 2.6 | ........ |
| Maximum | 12.4 | 3.6 | 12.5 | 7.6 | 62.0 | 2.9 | ........ |
| Average | **12.2** | **3.6** | **12.3** | **7.3** | **61.8** | **2.8** | **2** |
| Malt sprouts: | | | | | | | |
| Minimum | 7.3 | 3.8 | 21.0 | 9.3 | 45.5 | 1.0 | ........ |
| Maximum | 12.0 | 6.7 | 25.9 | 12.0 | 50.3 | 3.0 | ........ |
| Average | **10.2** | **5.7** | **23.2** | **10.7** | **48.5** | **1.7** | **4** |
| Brewers' grains, wet: | | | | | | | |
| Minimum | 68.6 | 0.3 | 4.3 | 3.1 | 9.6 | 0.8 | ........ |
| Maximum | 79.4 | 1.5 | 6.9 | 5.6 | 15.9 | 2.8 | ........ |
| Average | **75.7** | **1.0** | **5.4** | **3.8** | **12.5** | **1.6** | **15** |
| Brewers' grains, dried: | | | | | | | |
| Minimum | 6.2 | 2.4 | 19.3 | 10.2 | 37.4 | 4.2 | ........ |
| Maximum | 11.9 | 5.6 | 31.8 | 15.8 | 56.8 | 8.4 | ........ |
| Average | **8.0** | **3.4** | **24.1** | **13.0** | **44.8** | **6.7** | **15** |
| Distillery grains (dried), principally corn: | | | | | | | |
| Minimum | 5.0 | 1.1 | 24.9 | 8.9 | 32.2 | 7.8 | ........ |
| Maximum | 8.7 | 3.4 | 35.5 | 13.7 | 46.0 | 22.2 | ........ |
| Average | **7.0** | **2.0** | **29.2** | **11.0** | **39.4** | **11.4** | **12** |
| Distillery grains (dried), principally rye: Average | **6.8** | **2.1** | **17.3** | **12.3** | **54.0** | **7.5** | **3** |
| Grano gluten: Average | **5.9** | **2.7** | **31.0** | **11.4** | **34.8** | **14.2** | **3** |
| Atlas gluten meal: Average | **7.2** | **2.4** | **31.3** | **11.0** | **35.3** | **12.8** | **3** |
| Atlas gluten feed: Average | **7.4** | **1.7** | **31.1** | **11.0** | **36.3** | **12.5** | **11** |
| Rye bran: | | | | | | | |
| Minimum | 8.2 | 2.9 | 11.5 | 2.5 | 59.8 | 1.7 | ........ |
| Maximum | 13.7 | 4.5 | 16.8 | 4.1 | 67.6 | [illegible] | [illegible] |
| Average | **11.8** | **3.5** | **14.7** | **3.3** | **63.9** | [illegible] | [illegible] |

*Composition of feeding stuffs*—Continued.

| Feeding stuff. | Water. | Ash. | Protein. | Fiber. | Nitrogen-free extract. | Fat. |
|---|---|---|---|---|---|---|
| WASTE PRODUCTS—continued. | | | | | | |
| Wheat bran from spring wheat: | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* |
| Minimum | 7.4 | 4.0 | 14.3 | 5.4 | 51.7 | 3.6 |
| Maximum | 13.6 | 6.0 | 18.1 | 10.1 | 58.1 | 5.0 |
| Average | **11.5** | **5.4** | **16.1** | **8.0** | **54.5** | **4.5** |
| Wheat bran from winter wheat: | | | | | | |
| Minimum | 10.6 | 5.0 | 13.9 | 7.2 | 50.5 | 3.5 |
| Maximum | 13.6 | 6.4 | 17.8 | 8.9 | 56.2 | 4.5 |
| Average | **12.3** | **5.9** | **16.0** | **8.1** | **53.7** | **4.0** |
| Wheat bran, all analyses: | | | | | | |
| Minimum | 7.4 | 2.5 | 12.1 | 2.4 | 45.5 | 1.5 |
| Maximum | 15.8 | 7.8 | 18.9 | 15.5 | 63.2 | 7.0 |
| Average | **11.9** | **5.8** | **15.4** | **9.0** | **53.9** | **4.0** |
| Wheat middlings: | | | | | | |
| Minimum | 9.2 | 1.4 | 10.1 | 1.3 | 53.0 | 2.1 |
| Maximum | 16.0 | 6.3 | 20.0 | 12.7 | 70.9 | 5.9 |
| Average | **12.1** | **3.3** | **15.6** | **4.6** | **60.4** | **4.0** |
| Wheat shorts: | | | | | | |
| Minimum | 4.1 | 2.0 | 11.1 | 6.0 | 50.0 | 2.5 |
| Maximum | 15.5 | 6.2 | 19.4 | 10.5 | 67.0 | 6.1 |
| Average | **11.8** | **4.6** | **14.9** | **7.4** | **56.8** | **4.5** |
| Wheat screenings: | | | | | | |
| Minimum | 7.8 | 1.9 | 8.3 | 1.7 | 61.0 | 2.7 |
| Maximum | 13.6 | 3.8 | 16.9 | 7.5 | 70.4 | 3.3 |
| Average | **11.6** | **2.9** | **12.5** | **4.9** | **65.1** | **3.0** |
| Rice bran: | | | | | | |
| Minimum | 8.8 | 8.4 | 10.9 | 2.0 | 41.9 | 5.2 |
| Maximum | 10.7 | 12.4 | 13.6 | 17.8 | 62.3 | 10.9 |
| Average | **9.7** | **10.0** | **12.1** | **9.5** | **49.9** | **8.8** |
| Rice hulls: | | | | | | |
| Minimum | 7.7 | 10.5 | 2.9 | 30.3 | 36.0 | 0.6 |
| Maximum | 8.5 | 15.1 | 4.7 | 38.6 | 41.6 | 0.9 |
| Average | **8.2** | **13.2** | **3.6** | **35.7** | **38.6** | **0.7** |
| Rice polish: | | | | | | |
| Minimum | 9.0 | 2.8 | 10.9 | 2.4 | 45.5 | 6.5 |
| Maximum | 11.2 | 11.3 | 12.9 | 14.5 | 63.3 | 8.0 |
| Average | **10.0** | **6.7** | **11.7** | **6.3** | **58.0** | **7.3** |
| Buckwheat bran: | | | | | | |
| Minimum | 9.1 | 4.1 | 21.6 | 4.3 | 36.4 | 5.4 |
| Maximum | 12.1 | 5.4 | 31.4 | 20.3 | 42.3 | 8.9 |
| Average | **11.5** | **4.5** | **24.8** | **11.7** | **40.8** | **6.7** |
| Buckwheat middlings: | | | | | | |
| Minimum | 7.5 | 4.2 | 21.8 | 2.4 | 36.3 | 5.7 |
| Maximum | 16.3 | 6.2 | 35.9 | 12.9 | 52.7 | 9.2 |
| Average | **11.8** | **4.8** | **28.0** | **6.3** | **41.9** | **7.2** |
| Cotton-seed feed: | | | | | | |
| Minimum | 6.2 | 3.2 | 10.7 | 19.6 | 36.4 | 2.4 |
| Maximum | 9.7 | 4.4 | 22.6 | 37.4 | 42.0 | 6.0 |
| Average | **8.0** | **3.7** | **13.4** | **32.5** | **38.7** | **3.7** |
| Cotton-seed meal: | | | | | | |
| Minimum | 5.8 | 5.7 | 23.3 | 1.3 | 15.7 | 8.8 |
| Maximum | 18.5 | 8.8 | 50.8 | 10.1 | 38.7 | 18.0 |
| Average | **8.2** | **7.2** | **42.3** | **5.6** | **23.6** | **13.1** |
| Cotton-seed hulls: | | | | | | |
| Minimum | 9.2 | 1.8 | 2.2 | 37.9 | 12.4 | 0.6 |
| Maximum | 16.7 | 4.4 | 5.4 | 67.0 | 41.8 | 5.4 |
| Average | **11.1** | **2.8** | **4.2** | **46.3** | **33.4** | **2.2** |
| Linseed meal, old process: | | | | | | |
| Minimum | 5.6 | 4.6 | 27.7 | 4.7 | 28.4 | 5.2 |
| Maximum | 12.4 | 8.2 | 38.2 | 12.9 | 41.9 | 11.6 |
| Average | **9.2** | **5.7** | **32.9** | **8.9** | **35.4** | **7.9** |
| Linseed meal, new process: | | | | | | |
| Minimum | 6.0 | 4.9 | 27.1 | 5.9 | 32.1 | 1.3 |
| Maximum | 13.4 | 6.9 | 44.0 | 10.2 | 48.0 | 4.8 |
| Average | **9.9** | **5.6** | **35.9** | **8.8** | **36.8** | **3.0** |
| Peanut meal:[1] | | | | | | |
| Minimum | 6.6 | 3.7 | 37.5 | 2.5 | 28.5 | 5.8 |
| Maximum | 15.4 | 5.5 | 52.4 | 7.4 | 30.8 | 17.5 |
| Average | **10.7** | **4.9** | **47.6** | **5.1** | **23.7** | **8.0** |
| Peanut hulls: | | | | | | |
| Minimum | 7.8 | 1.9 | 4.6 | 56.5 | 9.7 | 0.9 |
| Maximum | 10.8 | 4.6 | 8.6 | 72.3 | 18.9 | 2.0 |
| Average | **9.0** | **3.4** | **6.6** | **64.3** | **15.1** | **1.6** |

[1] Mostly European analyses.

*Composition of feeding stuffs*—Continued.

| Feeding stuff. | Water. | Ash. | Protein. | Fiber. | Nitrogen-free extract. | Fat. | Number of analyses. |
|---|---|---|---|---|---|---|---|
| WASTE PRODUCTS—continued. | | | | | | | |
| Sugar-beet pulp: | | | | | | | |
| Fresh— | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | |
| Minimum | 88.5 | 0.1 | 0.6 | 1.9 | 5.4 | 0.1 | ...... |
| Maximum | 91.7 | 0.7 | 1.4 | 2.6 | 7.2 | 0.6 | ...... |
| Average | 89.9 | 0.4 | 1.0 | 2.2 | 6.3 | 0.2 | 7 |
| Dry— | | | | | | | |
| Minimum | | | | | | | |
| Maximum | 3.6 | 2.7 | 8.7 | 17.3 | 56.4 | 0.7 | ...... |
| Average | 10.8 | 4.1 | 12.1 | 22.4 | 59.6 | 1.7 | ...... |
| | 6.4 | 3.3 | 10.8 | 19.8 | 58.4 | 1.3 | 3 |
| MILK AND ITS BY-PRODUCTS. | | | | | | | |
| Whole milk: | | | | | | | |
| Minimum | 80.3 | 0.4 | 2.1 | ...... | 2.1 | 1.7 | ...... |
| Maximum | 90.7 | 1.2 | 6.4 | ...... | 6.1 | 6.5 | ...... |
| Average | 87.2 | 0.7 | 3.6 | ...... | 4.9 | 3.7 | 793 |
| Skim milk, cream raised by setting: | | | | | | | |
| Minimum | 88.3 | 0.5 | 2.6 | ...... | 3.8 | 0.2 | ...... |
| Maximum | 92.6 | 1.0 | 3.9 | ...... | 5.5 | 2.5 | ...... |
| Average | 90.4 | 0.7 | 3.3 | ...... | 4.7 | 0.9 | 90 |
| Skim milk, cream raised by separator: | | | | | | | |
| Minimum | 89.8 | ...... | ...... | ...... | ...... | ...... | ...... |
| Maximum | 91.2 | ...... | ...... | ...... | ...... | ...... | ...... |
| Average | 90.6 | 0.7 | 3.2 | ...... | 5.2 | 0.3 | 9 |
| Buttermilk: | | | | | | | |
| Minimum | 82.2 | 0.4 | 1.7 | ...... | 2.5 | ...... | ...... |
| Maximum | 93.3 | 0.9 | 6.2 | ...... | 5.6 | 5.4 | ...... |
| Average | 91.0 | 0.7 | 3.0 | ...... | 4.8 | 0.5 | 85 |
| Whey: | | | | | | | |
| Minimum | 93.2 | 0.3 | 0.3 | ...... | 4.4 | 0.0 | ...... |
| Maximum | 94.6 | 0.6 | 1.2 | ...... | 5.8 | 0.2 | ...... |
| Average | 93.8 | 0.4 | 0.6 | ...... | 5.1 | 0.1 | 46 |
| POULTRY FOODS. | | | | | | | |
| Animal meal: | | | | | | | |
| Minimum | 2.38 | 33.39 | 25.20 | ...... | ...... | 7.26 | ...... |
| Maximum | 8.38 | 43.54 | 48.53 | ...... | ...... | 21.80 | ...... |
| Average | 5.67 | 39.88 | 39.42 | ...... | ...... | 10.78 | 35 |
| Meat or beef scrap: | | | | | | | |
| Minimum | 5.40 | 11.72 | 36.69 | ...... | ...... | 12.31 | ...... |
| Maximum | 12.59 | 21.70 | 66.81 | ...... | ...... | 30.90 | ...... |
| Average | 7.86 | 17.39 | 49.72 | ...... | ...... | 18.51 | 33 |
| Meat or beef meal: | | | | | | | |
| Minimum | 6.08 | ...... | 35.10 | ...... | ...... | 6.83 | ...... |
| Maximum | 6.44 | ...... | 66.20 | ...... | ...... | 19.50 | ...... |
| Average | 6.27 | ...... | 48.36 | ...... | ...... | 12.90 | 14 |
| Meat and bone: | | | | | | | |
| Minimum | 3.79 | ...... | 24.22 | ...... | ...... | 5.89 | ...... |
| Maximum | 9.74 | ...... | 58.71 | ...... | ...... | 13.06 | ...... |
| Average | 5.68 | ...... | 36.66 | ...... | ...... | 10.49 | 7 |
| Bone meal (Bowker's) | ...... | ...... | 34.00 | ...... | ...... | 2.20 | ...... |
| Fresh bone | 34.20 | 22.80 | 20.60 | ...... | 1.90 | 20.50 | ...... |
| Cut bone | 26.29 | 15.85 | 15.20 | ...... | ...... | 23.13 | ...... |
| Boiled beef bone: | | | | | | | |
| Minimum | 4.10 | ...... | 40.76 | ...... | ...... | 11.44 | ...... |
| Maximum | 8.16 | ...... | 48.09 | ...... | ...... | 18.70 | ...... |
| Average | 5.68 | ...... | 44.75 | ...... | ...... | 17.11 | 5 |
| Clover meal: Average | 7.77 | ...... | 10.51 | ...... | ...... | 1.86 | 3 |
| H. O. Poultry Food: | | | | | | | |
| Minimum | 6.66 | 2.52 | 15.00 | 2.86 | 60.46 | 4.67 | ...... |
| Maximum | 10.80 | 3.01 | 17.88 | 5.13 | 64.35 | 6.36 | ...... |
| Average | 8.49 | 2.64 | 16.83 | 4.56 | 62.01 | 5.47 | 20 |
| American Poultry Food: | | | | | | | |
| Minimum | 7.22 | 2.67 | 8.31 | 4.33 | 60.49 | 4.82 | ...... |
| Maximum | 11.15 | 2.96 | 15.53 | 7.20 | 63.47 | 7.40 | ...... |
| Average | 9.16 | 2.81 | 13.22 | 5.48 | 63.18 | 6.15 | 24 |

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number and title of each. Copies will be sent to any address on application to any S
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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 26.
(Revised.)

# weet Potatoes: Culture and Uses.

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BY

J. F. DUGGAR, M. S.,
*Professor of Agriculture, Agricultural and Mechanical College of Alabama.*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1900.

## LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Office of Experiment Stations,
*Washington, D. C., September 7, 1900.*

Sir: I have the honor to transmit herewith copy for a revised edition of Farmers' Bulletin No. 26, Sweet Potatoes: Culture and Uses, and to recommend its publication. The wearing out of the plates from which former editions were printed has given an opportunity to revise and perfect the text of this bulletin, but no important changes have been made, and no new matter has been included.

Very respectfully,

A. C. True,
*Director.*

Hon. James Wilson,
*Secretary of Agriculture.*

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# SWEET POTATOES: CULTURE AND USES.

## INTRODUCTION.

The sweet potato (*Ipomœa batatas*) belongs to the morning-glory family (*Convolvulaceæ*). The enlarged root is prized as a vegetable, while the long vines are not generally utilized, although of value as a food for live stock.

Authorities have not been able to agree whether the sweet potato owes its origin to America or to the East Indies. In the warmer regions of both the Eastern and the Western continents it is extensively cultivated.

According to the census of 1890, the United States produces annually in round numbers 44,000,000 bushels of sweet potatoes. The eighteen States growing the greatest quantities are as follows:

| | Bushels. | | Bushels. |
|---|---|---|---|
| North Carolina | 5,665,391 | Louisiana | 1,912,080 |
| Georgia | 5,616,317 | Arkansas | 1,822,960 |
| Texas | 5,505,452 | Florida | 1,749,679 |
| Alabama | 4,339,170 | Kentucky | 904,125 |
| Mississippi | 3,207,125 | Missouri | 561,551 |
| South Carolina | 3,061,040 | Kansas | 533,846 |
| Virginia | 2,816,041 | Illinois | 451,125 |
| New Jersey | 2,254,344 | Maryland | 408,549 |
| Tennessee | 1,973,625 | Delaware | 202,914 |

New Jersey is the most northerly State in which sweet potatoes are extensively cultivated. However, good crops have been matured at Geneva, N. Y., and Lincoln, Nebr., on the grounds of the agricultural experiment stations. In gardens still farther north the sweet potato has been cultivated. Maine, for example, is credited in the last census with 267 bushels.

## PROPAGATION BY SETS.

The sweet potato is most commonly propagated by means of the buds or shoots from the roots. The roots are planted in open beds, cold frames, or hotbeds, and the buds or shoots which develop are removed and transplanted in the field. In some localities the cuttings or sections from the vines secured by the above method of propagation are transplanted, and the plants thus obtained produce the bulk of the crop. It is possible to propagate by planting true seed or by planting portions of the root, as with Irish potatoes. The sweet potato rarely matures seed in the United States, although true seeds have been produced in greenhouses. The sprouts or shoots from the parent root have different local names. In this bulletin they will be referred to as sets.

## THE PLANT BED.

To secure the sets for transplanting, the eyes or buds on the sweet potato must be sprouted. For this purpose considerable heat is required, and germination takes place in especially prepared open beds, in cold frames, or in hotbeds, the kind of bed used depending on the climate and on the degree of forcing desired. For an early crop, bottom heat is desirable. This is provided either by the fermentation of manure or by flue heat from a small furnace, the former method being most frequently employed. The latter method, however, permits of a more complete regulation of the amount of heat, and has other advantages which recommend it to those who cultivate the sweet potato on a large scale for market.

For the sweet-potato-plant bed select a location somewhat protected on the north side. Build an ordinary plank cold frame 6 feet wide and of any length desired, facing toward the south and having its north wall several inches higher than its south wall. On the outside bank dirt against the frame and protect the bed against drainage water by a shallow drain around the outside. Protect the bed against moles by means of a drain or by planking the frame below the surface of the ground.

Within the frame remove the earth to a depth of 2 to 12 inches; spread a thin layer of leaves or litter on the bottom of this excavation to assist in draining the bed and to retain the heat. Then on this litter place a layer of manure 2 to 12 inches thick, the thickness of the layer depending on the amount of heat required. Level and pack the manure and on it place a layer of sand or soil 1½ to 3 inches thick. On this place the sweet potatoes in a horizontal position, not touching each other. If large roots are used they may be split lengthwise, placing the cut surface downward. Cover with sand, soil, or fine woods earth until the upper side of the sweet potato is covered at least 1 inch deep, or better 2 to 3 inches deep.

After the sweet potatoes are covered the upper surface of the earth within the frame will be either on a level with the ground outside or 1 to 6 inches above the level of the surrounding soil, according to the depth of excavation made in starting the bed. A bed with its surface considerably higher than the surrounding soil is better drained, but is liable to suffer from drought or to require more watering than a lower bed.

The amount of manure required depends on climate, season, character of manure, and to a less degree on some other factors. Experienced growers in localities where early sweet potatoes are grown for market endeavor to use such an amount of manure as will keep the soil around the bedded roots at about 75° to 80° F.; during the first few days after bedding, the soil is sometimes allowed to warm up to 85° or 90°. In the Gulf States the usual depth of manure is 2 to 5 inches, while in New Jersey a depth of 12 inches is not uncommon. The manure should be ther coarse horse manure which has not been repeatedly heated; hen applied it should be moistened, and then leveled and packed. the Southern States a layer of 2 to 4 inches of thoroughly moistened tton seed is sometimes substituted for manure. In some localities in e South it is customary to cover the bedded sweet potatoes with 3 or inches of soil, and when the sprouts are nearly ready to come up, to ke off 1 or 2 inches of the covering. This serves as a cultivation d destroys weeds if any are present. If the potatoes are covered allow, a thin covering of earth may be added just as the sprouts gin to appear.

The movable cover of the bed may be either of litter, boards, cloth, glass, depending on climate, season, and degree of forcing desired. lass is most satisfactory when an early crop is desired, but its expense against its use in many cases, and cloth oiled with linseed oil is substituted. The labor involved in moving litter of any kind, as pine edles, straw, marsh hay, etc., to admit the sun during the warmer rt of the day is considerable, and in most cases a cloth cover is more tisfactory. After the sprouts appear above ground they should be ughened by a process of gradual exposure to the outside air, raising removing the cover in suitable weather. The bed should be kept oist, but not wet. If necessary the bed should be watered before and ter the appearance of the sets, and should be protected against heavy d cold rains.

If the heat from the fermenting manure becomes excessive it may be duced by removing the cover of the plant bed, by making small holes the soil down to the layer of manure, or by the application of water.

The preparation of a plant bed in which artificial heat is used is thus scribed by a sweet-potato grower in New Jersey:

> Select a location where sufficient rise can be had, say 1 foot in 20. ild a furnace of brick to burn coal or wood; if you wish to use wood ild not less than 2 by 2 by 5 feet. The top of the furnace should be pressed about 3 feet below the bed and covered with soil so as to oid danger of fire. Take 3 rows of 5 or 6 inch tile for flues and run em about three-fourths the length of bed; here we have a hot-air ace about 1 foot deep running all under the bed. Cover this space th boards and put a board chimney at the upper end, with damper to gulate draft. Keep damper well closed to hold the heat. Beds ould be about 12 feet wide and from 48 to 100 feet long.

On the plank floor of the bed is spread a layer of about 5 inches of nd or soil. On this the potatoes are placed and then covered with rth as in a bed warmed by manure. The flues may be made of brick stead of tile. As an extra precaution against fire a coat of asbestus int may be applied to the woodwork of the bed. The bottom of the d may be level; the slope of the ground giving the necessary grade the flue, and the hollow space between the bottom of the bed and e ground should be closely boarded in. By excavating, the bed may brought down to the level of the ground around.

Another successful sweet-potato grower has a sweet-potato bed with furnace and brick flues, arranged as shown in the diagram (fig. 1). The flues have a slight grade and terminate in a chimney directly over the furnace. The 4-inch space between the double wooden walls which inclose the hot-air space below the bed is filled with sawdust. The 2 by 4-inch studs of this wall, which support the bed, are 3 feet long. Earth is heaped against the walls on the outside.

### PERIOD OF GROWTH OF SETS.

The sweet potatoes intended for seed purposes should be bedded 5 or 6 weeks before the date on which it is expected to transplant the first lot of sets.

The sets are large enough for transplanting when their length above ground is 3 to 5 inches if they are sufficiently tough to admit of handling. If they are ready before a safe date for setting in the field or before the ground is ready, Oemler recommends that they be detached from the parent roots, and in a protected situation "heeled in," like strawberry plants awaiting transplanting. Their early removal allows younger sprouts an opportunity for growth. At least three crops of sets—three "drawings"—may be obtained, although growers desiring an early crop may be able to utilize only one or two of these drawings. The sweet-potato plant is very susceptible to cold, and the sets can not be transplanted with safety until danger of frost is past.

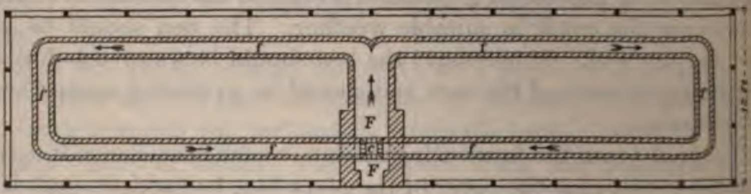

FIG. 1.—Sweet-potato bed, with furnace and flues.

*F*, furnace; *fff*, flue; *c*, chimney. The arrows indicate the direction of the hot-air current.

Sweet-potato growers report the following dates as the earliest at which they consider it safe to set out sweet-potato plants for an early crop: Near Jacksonville, Fla., March 20 to April 1; South Carolina, Georgia, Alabama, Mississippi, and Arkansas, April 1 to 25, and the southern part of New Jersey, May 1 to 15. For the main crop the latter part of May is preferred in New Jersey, and May and June in the Gulf States. At Knoxville, Tenn., at an altitude of about 9 feet, the Experiment Station obtained larger yields by transplanting May 4 than at earlier or later dates. Very early planting is desirable only where an extra-early crop can be marketed at a high price. To get the healthiest growth of plants, large yields, and roots with the best-keeping qualities, transplanting should be postponed until the soil becomes thoroughly warm.

inety days after transplanting is generally regarded as the shortest
od required for growth before the early varieties of sweet potatoes
:eady to be dug for the family table or for the market, though some
vers report 75 days, and a few even 60 days, as the minimum
od between transplanting and early harvesting. Such rapid
:lopment, however, is to be expected only in peculiarly favorable
ons, with late transplanting, and for early varieties.

### AMOUNT AND CHARACTER OF SWEET POTATOES USED FOR SEED.

nce sweet potatoes of every size, from that of a cigar upward, are
led, the amount of seed potatoes required to fill a plant bed of
n dimension or to furnish sets for an acre varies within certain
: limits. The larger the potatoes the smaller the amount of plant-
space necessary to accommodate a bushel, the smaller the number
ets per bushel of bedded roots, and the greater the number of
iels of seed potatoes required to furnish sets for an acre.

he space in the plant bed covered by 1 bushel of large sweet
.toes is estimated at 9 to 17 square feet; by 1 bushel of medium-
l roots, 17 to 25 square feet; by 1 bushel of small potatoes, 21 to 32
ıre feet. These limits are for roots bedded with customary thick-
, but they lack exactness because there is no definite standard for
rmining whether a sweet potato is large, small, or medium in size.

he quantity of seed potatoes required by an acre varies even more
:ly than does that for a given plant bed, by reason of the fact that
more crops of sets are produced. Moreover, the number of plants
acre varies in different localities from 5,000 to 10,000. Hence the
›wing figures are presented only as rather rough estimates: An
:rienced New Jersey truck farmer reports that he is able to utilize,
ng the entire planting season (which is comparatively short in New
ey), 2,500 sets from every bushel of small seed potatoes bedded.
n two other localities we have an estimated yield of 2,000 sets
ined at the first drawing from a bushel of sweet potatoes classed
nedium in size, a result which seems to be too favorable to be
:cted under ordinary circumstances. Experience appears to justify
following approximate estimates of the amounts of seed sweet
.toes required to furnish sets (not cuttings) for an acre: When sets
drawn repeatedly, small potatoes, 1½ to 2 bushels; medium-sized
.toes, 2 to 4 bushels; large potatoes, 4 to 10 bushels. To plant an
with sets obtained at first drawing, these quantities should be
oled.

localities where the chief dependence is on vine cuttings from early
ts, much smaller amounts of seed will suffice. A Texas farmer
ined from 1 acre of plants propagated by sets sufficient vine
ings to supply 2 or more acres; another in Florida cut from 1 acre
s enough to set out 4 acres. This necessitates such close pruning
ie growing vines as probably to affect the yield on the area pruned.

It appears that variety as well as size is a factor in determining the quantity of seed potatoes, for one grower rates Southern Queen 50 per cent higher than Yellow Nansemond in reproductive power, and another considers it necessary to use only one-third as much seed for White West India as for Providence.

At the Alabama College Experiment Station in 1891 the gain in yield from using sets from large rather than small sweet potatoes was considerable. At the Georgia Station large and small potatoes gave practically identical yields.

Whether large or small potatoes should be selected for seed is a mooted question among farmers, and the above-mentioned experiments are not decisive. Small potatoes are most used, chiefly, perhaps, on account of their unfitness for other purposes. It is much in their favor that a bushel affords a relatively large number of sets. Small potatoes about an inch in diameter, grown from vine cuttings, are preferred on the Eastern Shore of Virginia, because they keep better and are believed to give hardier sprouts than sweet potatoes grown from sets.

There are those who assert that if small and unshapely roots are planted the quantity and quality of the resulting crop will be injuriously affected. For many cultivated plants with true seeds it has been shown that large and perfect seeds yield better returns than small and deformed seeds. The sweet-potato root, however, is not a seed; nor is it in the same class with the Irish potato tuber, with which medium to large have generally given better yields than small potatoes. The Irish potato continues for a long time as a storehouse of food for the growing plant; hence the larger the storehouse the more vigorous the growth of the plant; the sweet potato set, however, is early detached from this source of nourishment and in the field receives no parental aid.

While admitting the need of more information in regard to the best size of seed sweet potatoes, we think it advisable to plant short, well-formed roots of medium or small size and of perfect soundness.

### PROPAGATION BY VINE CUTTINGS.

Propagation of sweet potatoes by means of vine cuttings is of great economic importance, this method being in general use in the Gulf States and in other States with a similar climate. Even as far north as the counties of Virginia lying along the Chesapeake Bay small roots to be used as seed potatoes in the following spring are obtained by setting out vine cuttings.

The data furnished by growers seem to indicate that as a general rule vine cuttings can be set out with advantage until within 90 to 105 days before the average date at which the first autumn frost occurs in a given locality.

Experiments comparing the yield from sets and from vine cuttings were conducted at the Alabama Agricultural College in 1884 and

86. The results taken as a whole were slightly in favor of vine ttings. At the Louisiana Station sets gave larger yields than vine ttings. The crop from plants propagated by vines generally contains arger percentage of small potatoes, a natural result of the shorter ne usually allowed for this crop to mature. The use of cuttings tead of sets effects a great economy in seed potatoes.

At the Louisiana Experiment Station sweet-potato vines were pruned ekly to a length of 2 feet. The pruned vines yielded considerably s than the vines that were not pruned, and this in a year when owth was very vigorous. Pruning resulted in increasing the per- ntage of small potatoes, a condition which should be avoided.

## SOIL—CHARACTER AND PREPARATION.

The sweet potato makes its best growth on a warm, sandy, well- ined, or even dry soil. Light loams are also suitable. Recently ared ground, if susceptible of thorough preparation, is suitable for sweet potato, provided it is entirely free from shade. For cold, npact clay this plant seems to have an aversion. On Southern farms sweet potato is too often relegated to the poorest fields, under the rcely tenable, but widely current, opinion that a rich soil or liberal nuring makes luxuriant vines at the expense of the roots. The soil uld be of such texture and color that it will not adhere to and stain roots. Clay adheres to the roots and injures their appearance; d is easily rubbed off in handling.

Weeds are troublesome and expensive visitors in the sweet-potato d, and hence the crop should follow a hoed crop. An exception haps to this rule is the growth of crimson clover to be plowed under April or May as a green manure for the sweet-potato plant.

To secure the short, well-shaped potatoes, which the large markets fer, it is customary in truck-farming regions with sandy soil to plow y shallow, only 3 or 4 inches deep. Stiffer, less permeable soils are wed deeper. It can scarcely be doubted that deep plowing on all s, except perhaps on those which are very light and loose, largely reases the yield of sweet potatoes, whatever its effect on the shape the roots. Hence those who do not grow sweet potatoes for ship- nt can advantageously plow deeper for this crop than can truck ners. After thorough preparation with plow, harrow, and roller low ridges are formed and on their flattened tops the sets or vines transplanted.

## TRANSPLANTING.

Most growers prefer to set the plants in moist, recently prepared soil. hers make a slight ridge a few weeks in advance of transplanting, just before putting out the plants plow fresh dirt to this ridge. ly experience in each locality can determine whether the ridges for sweet potatoes should be low or high. As a general rule crops g on low ridges give larger yields, provided the season of growth is and the land well drained and warm; high ridges are warmer and subject to drought, but are sometimes advantageous on cold, undr soil and for an early crop. At the Georgia Experiment Station in 3 varieties averaged 255 bushels per acre when grown on ridges, 277 bushels when cultivated level, a difference of 22 bushels per in favor of flat cultivation. On the other hand, at Baton Rouge, the Louisiana Experiment Station found that high ridges gave la yields than low ridges or level cultivation.

By planting in checks instead of in drills and by plowing in directions hand labor is saved in cultivation. The hills may be entirely by the plow, or by both plow and hoe. Opinions differ whether planting in drills or in hills is more profitable. In dr greater number of plants can be grown, and somewhat larger y are generally obtained than by checking; the advantage of chec consists in the saving of labor.

### LABOR-SAVING TRANSPLANTERS.

The sprouts or sets when 3 to 5 inches long above ground are fully removed from the bed without dislocating the parent potato. sets are dropped on top of the ridges and transplanted with fingers, with a dibble or paddle, or with a pair of homemade wo tongs, constructed of two pieces of laths or small strips 3 feet separated by a block nailed between them at one end; the stri their free ends are about 1 inch apart and are easily pressed tog by the grasp of the hand in seizing the set. A rod carried i other hand is used to press the soil around the plant. This de largely used in New Jersey and Delaware, relieves the planter stooping and hastens the work. A transplanter worked by 2 h and 3 men was favorably reported in Bulletin 21 of the Florida Sta It sets and waters from 3 to 6 acres per day of tobacco, tomato, or s potato sets. It is not arranged for setting vine cuttings. The barrier to its more extensive use is its cost, said to be about $75. setting out vines a stick with fork or concave surface at the lowe and as long as a walking stick is in general use.

If the ground is dry at the time of transplanting it may be nece to water the sets or vines as they are placed in position, immedi afterwards drawing dry dirt up to the plant to hinder evapor The practice of setting out sweet potatoes while the ground is ver is to be condemned, especially if the soil contains much clay. Di the lower part of the set in a paste made of soil and cow man sometimes practiced when the sets are to be placed in rather dr without watering. The afternoon is better than the morning for planting. The missing hills should be replanted as soon as pos

In Kansas the sweet-potato plant has been subjected to irrigation, with satisfactory results, both as to quantity and quality of crop.

### DISTANCE BETWEEN PLANTS.

In an experiment at Baton Rouge, La., sweet-potato plants were placed 8, 12, 15, and 18 inches apart in rows spaced 3½ feet. The average yields of merchantable roots for 3 years were as follows: At 8 inches apart, 252 bushels per acre; 12 inches, 258 bushels; 15 inches, 275 bushels; 18 inches, 281 bushels. At the Georgia Experiment Station a distance of 2 feet between plants in rows 3½ or 4 feet apart afforded the largest yield in certain years, although in 1893 a distance of 18 inches gave best results.

When sweet-potato plants are grown in checks a distance of 30 by 30 inches is the least that is convenient, and this affords about 7,000 hills per acre.

### CULTIVATION.

Sufficient cultivation should be given to the growing plants to keep the surface soil loose and free from weeds. Two to four plowings with the cultivator and one or two hoeings should suffice. After the vines begin to run plowing can be done only by moving the vines with a pronged hoe or hook in advance of the plow, or better by using a cheap vine-lifting attachment on the cultivator. Dirt should never be thrown on the vines, and all cultivation should be shallow.

Many growers are careful to prevent the vines taking root at the joints. Peter Henderson has stated that in the northern part of the sweet-potato region if the vines are allowed to root freely the potatoes will be small and nearly worthless. However, at the Louisiana Station at Baton Rouge sweet-potato vines undisturbed yielded 352 bushels of marketable sweet potatoes per acre, while vines lifted twice per week yielded only 226 bushels.

Sweet-potato growers in a number of States were asked whether their experience justified the expense of moving the vines after the last cultivation. About 70 per cent of them answered in the negative. The gist of the matter seems to be this: Moving the vines after cultivation ceases costs too much labor to be advantageous, except possibly when cultivation is discontinued early or when, on rich, moist soil, a heavy rain falls within about two weeks after the last cultivation.

### MANURING.

Before noting the actual results secured in fertilizer experiments let us consider the amount of fertilizing material contained in the roots and vines of an acre of sweet potatoes. In a highly fertilized field near Washington, D. C., the writer weighed the sweet-potato roots and vines growing on a large plat. The roots averaged 17,898 pounds per acre, or about 350 bushels. The vines on this plat were luxuri and when cut, October 1, 1894, completely covered the ground. yield of fresh vines was 10,374 pounds per acre.

According to analyses made at the New Jersey Experiment Sta fresh sweet-potato roots contained 0.23 per cent of nitrogen, 0.1 phosphoric acid, and 0.50 of potash.

The fresh vines referred to above were analyzed in the Divisio Chemistry of this Department, with the follow result: Water, 8 per cent; nitrogen, 0.42; phosphoric acid, 0.07; potash, 0.73; li 0.44; total ash, 2.45.

If we assume 10,000 pounds of roots (equivalent to 185 bushels) 8,000 pounds of vines per acre as a fair yield, we have the follow figures showing the amounts of fertilizing ingredients containe roots and vines of a crop of this size:

*Fertilizing ingredients in roots and vines of sweet potatoes.*

| | In roots. | In vines. |
|---|---|---|
| | *Pounds.* | *Pounds.* |
| Nitrogen | 23 | 34 |
| Phosphoric acid | 10 | 6 |
| Potash | 50 | 58 |

Much more potash than nitrogen and much more nitrogen phosphoric acid is appropriated by the sweet potato, and this is whether we look only at the roots, the part always removed from soil, or at the entire growth of roots and vines.

Assuming that sweet-potato vines are left on the land and that wh straw is finally returned to the soil from which it came, we find 185 bushels of sweet-potato roots remove practically as much nitro and phosphoric acid and more than seven times as much potash as bushels of wheat.

The amounts of nitrogen, available phosphoric acid, and potash tained in a sweet-potato crop of 185 bushels of roots and 8,000 po of vines would be supplied by the following amounts of comme fertilizers:

*Amounts of different fertilizers needed to supply fertilizing ingredients in a crop potatoes, including vines.*

| 57 pounds nitrogen in— | 16 pounds[1] available phosphoric acid in— | 108 pounds potash in— |
|---|---|---|
| 363 pounds nitrate of soda, or<br>542 pounds dried blood, or<br>803 pounds cotton-seed meal, or<br>11,600 pounds barnyard manure. | 96 pounds dissolved boneblack, or<br>138 pounds superphosphate.[2] | 210 pounds muriate of<br>320 pounds sulphate of<br>793 pounds kainit, or<br>475 pounds cotton-hull ash |

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[1] According to an analysis made at the Texas Experiment Station about 25 pounds of ph acid, i. e., 150 pounds of dissolved bone or 215 pounds superphosphate, is required.

[2] Called also acid phosphate and dissolved South Carolina rock, and containing 11.6 per ce able phosphoric acid.

It may be considered sufficient in some cases to apply only the quan-
y of fertilizing material that is removed by the roots of the sweet
tato, the vines being left on the ground. Ten thousand pounds of
eet-potato roots contain fertilizing ingredients equal to those found
the kinds and amounts of fertilizers given below:

*ounts of different fertilizers needed to supply the fertilizing ingredients of 10,000 pounds of sweet potatoes.*

| 23 pounds nitrogen in— | 10 pounds available phosphoric acid in— | 50 pounds potash in— |
|---|---|---|
| pounds nitrate of soda, or<br>pounds dried blood,[1] or<br>pounds cotton-seed meal,[2] or<br>pounds barnyard manure.[3] | 60 pounds dissolved boneblack, or<br>86 pounds superphosphate. | 97 pounds muriate of potash, or<br>150 pounds sulphate of potash, or<br>367 pounds kainit, or<br>220 pounds cotton-hull ashes.[4] |

[1] Containing also about 4 pounds of phosphoric acid.

[2] Containing also about 10 pounds of phosphoric acid and 6 pounds of potash.

[3] Containing also about 15 pounds of phosphoric acid and 20 pounds of potash.

[4] Containing also about 17 pounds of available phosphoric acid.

These figures are not given as representing the exact amounts of
tilizing materials which should be applied to sweet potatoes, for the
nt draws a part of its food from the soil, and soils vary widely in
tility, one soil being especially poor in potash, another in nitrogen,
l so on. On the other hand, a part of the fertilizer applied to a par-
ular crop is completely lost in the drainage water or becomes unavail-
e in the soil. The only way to be sure of the amount of fertilizer
ich can be advantageously used on a given field is to experiment.

lthough not absolute guides in manuring, the results of analyses of
sweet potato are of value, in that they emphasize the special need
potash either in the soil or in the fertilizer for this crop. Another
son for using potash fertilizers is the fact that sandy soils, which
preferred for sweet potatoes, are frequently deficient in potash.

n practice it is customary and apparently advantageous to use more
sphoric acid than the crop contains, since phosphates, when added
he soil, largely enter into forms in which they are not immediately
ilable to plants.

he opinion is prevalent that nitrogenous fertilizers stimulate the
wth of sweet-potato vines at the expense of the roots. A careful
mination of all the experiments on this crop published by the exper-
nt stations leads to the conclusion that nitrogen when applied in con-
tion with phosphoric acid and potash increases the crop of roots in
t instances. From results secured by the New Jersey and Louisiana
eriment Stations, it appears that heavy applications of nitrogenous
ilizers under some conditions injure the quality of the crop. The
et-potato plant must have nitrogen; it has, however, a long growing
on extending through all the hot months, when nitrification is
ve in soils filled with vegetable matter, and hence it may thrive on
h soils, which contain a large amount of nitrogen in a more or less
tive form, without the direct application of nitrogenous fertilizers.

The sweet potato flourishes on a soil rich in vegetable matt hence it is usual for truck farmers to apply very large quant composted pine needles, woods earth, etc., to the sweet-potat By plowing under leguminous plants, as the clovers and cow large quantity of nitrogen, obtained by the leguminous crop fr atmosphere, can be economically added to the soil. In an exp in Delaware crimson clover plowed under in the spring very increased the yield of sweet potatoes.

In most of the experiments on record phosphoric acid has give increase in the sweet-potato crop, an increase usually sufficient der profitable the use of phosphoric acid in combination with ni and potash. Its employment alone on sweet potatoes is not ge advisable.

Potash appears to be the most important fertilizer for sweet po In the great majority of experiments it has been profitably em either with nitrogen and phosphoric acid or alone. In nearly all ments a complete fertilizer—that is, one containing nitrogen, phoric acid, and potash—has largely increased the crop and safest to use until experience has shown that one of these const can be omitted without loss in any given locality.

In deciding on the best form of nitrogen, phosphoric acid, and for sweet potatoes we have some help from experiments, but th ber of such experiments is as yet too limited to admit of defini clusions on this point. In New Jersey, in some soils and seasons gen in the form of nitrate of soda has given larger yields than form of dried blood; in other soils and seasons dried blood has superior. In Georgia the nitrogen of nitrate of soda gave better diate results than that of cotton-seed meal and stable manure. of soda is more soluble than the other nitrogenous fertilizers acts more quickly, and in a rainy season and on "leachy" soil liable to be washed out of the reach of plants. We should exp results when the sweet potato is supplied with nutrients at all of its long season of growth, as, for example, when nitrate and dried blood or cotton-seed meal are applied together, the fo give the plant a good start and one of the latter to become av later in the plant's life. In practice such a mixture has been advantageous.

Phosphoric acid may be purchased, not only in dissolved bo and acid phosphate (superphosphate), but in floats, slag, and i forms. Both floats and slag contain a larger amount of phospho than dissolved boneblack and superphosphate, but in a more ble form.

The best potash fertilizer for sweet potatoes is probably that i a pound of potash costs least. Near seaport cities this is ordi low-grade fertilizer, such as kainit; farther inland the cost of portation may make the concentrated forms, such as muriate and sulphate of potash, relatively cheaper.

Horse manure at the rate of 10 to 20 tons per acre is the chief reliance of market gardeners near large cities for manuring the sweet potato. The New Jersey Experiment Station has shown that commercial fertilizers may be profitably substituted for a part or for the whole of the stable manure when the latter costs about $2 per ton at the farmer's depot. The crops from chemicals were equally as large as from stable manure, and the quality, as indicated by the appearance of the skin, was better. The cost of chemical fertilizers was less than that of a quantity of stable manure sufficient to produce equally large crops. Stable manure has one great advantage over chemical fertilizers in that the effects of the former are apparent for a greater number of years after application. While it is often unwise to purchase stable manure, it is always profitable to use that produced on the farm. It should be well rotted before use on a sweet-potato field.

The following formulas are among those which have given good results at some of the experiment stations:

*Fertilizer formulas for sweet potatoes.*

| Kind and amount of fertilizer per acre. | Nitrogen. | Available phosphoric acid. | Potash. |
|---|---|---|---|
| I. | *Pounds.* | *Pounds.* | *Pounds.* |
| 150 pounds of nitrate of soda | 24 | 41 | 77 |
| 350 pounds superphosphate | | | |
| 150 pounds muriate of potash | | | |
| II. | | | |
| 280 pounds dried blood | 29 | 53 | 82 |
| 320 pounds boneblack | | | |
| 160 pounds muriate of potash | | | |
| III. | | | |
| 100 pounds nitrate of soda | [*] 114 | [†] 27 | 113 |
| 160 pounds boneblack | | | |
| 80 pounds sulphate of potash | | | |
| 10 tons barnyard manure | | | |
| IV. | | | |
| 360 pounds cotton-seed meal | 26 | [‡] 43 | 94 |
| 320 pounds superphosphate | | | |
| 640 pounds kainit | | | |

[*] The manure supplies 98 pounds of nitrogen, the nitrate of soda only 16 pounds.
[†] In addition to 64 pounds of phosphoric acid in stable manure.
[‡] In addition to 11 pounds of phosphoric acid in cotton-seed meal.

These formulas probably supply larger quantities of fertilizers than farmers growing sweet potatoes for home use alone, and on soil already rich, would regard as advantageous. It is believed that to soils poor in nitrogen, phosphoric acid, and potash these formulas will supply the fertilizing ingredients in about the correct proportions. To secure the best results it may often be desirable for the planter to purchase the materials separately and mix them at home, varying the proportions of each ingredient to suit the conditions existing on his own farm.

## HARVESTING AND STORING.

The high price of extra early sweet potatoes induces early digging. The first early New Jersey sweet potatoes are usually shipped on or before August 15. Sweet potatoes are palatable as soon as they are large enough for the table, and hence it is not necessary to wait for the maturity of the roots if they are to be used soon after digging. According to the best information attainable, early digging yields only one-half to two-thirds of the crop which would be secured by waiting until nearly time for frost. A New Jersey truck farmer reports a test of this question. On a field set out rather late the weight of roots doubled between the last of August and the middle of October.

For the main crop the farmer can wait until growth is completed, and thus secure the maximum yield. A rule sometimes given for determining ripeness is this: Break several potatoes and expose the pieces to the air for some time. If sufficiently mature to keep well the original color is maintained; if unripe the broken surface assumes a dark or greenish appearance.

Sweet potatoes should be dug only when the ground is dry and before severe frost occurs. Dig in the forenoon, and after several hours' exposure gather the potatoes in baskets or boxes, the latter holding about a bushel each. Before digging the vines are cut and drawn from the row with a sharp hoe; the hand, the hoe, or the plow is used to dig the roots. A light turning plow with rolling coulter run once on each side of the row has been recommended as a means of cutting off a large portion of the vines. The potatoes may be assorted into two or three grades either in the field or at the place where they are to be stored. The greatest care is necessary to prevent bruising the potatoes in handling, for their skins are exceedingly tender, and wounded or bruised roots are almost sure to decay.

There is need for further investigation to determine the best methods of storing sweet potatoes, for the losses occurring during storage are sometimes enormous. In the colder parts of the sweet-potato region, where artificial heat is necessary to prevent freezing, we hear less complaint of rotting during winter than in the States where it is customary to store sweet potatoes in kilns or banks covered with litter and earth.

In Delaware, New Jersey, and some other States tightly built houses are constructed for storing this crop, and by means of a stove these houses are kept quite warm for a week or two after the potatoes are put in, and at 47° to 65° F. during the rest of the winter.

The following extract from a paper by a New Jersey truck farmer, giving his method of storing sweet potatoes, may convey useful information to growers in other localities:

> The floor of the storage room should not be tight, and beneath should be a cellar to contain a coal stove, by which the temperature

room may be raised to 100° F. The storage room should have full tilation at top and sides.

Vhile the potatoes are being stored from the field keep up the heat to degree named and dry off all moisture as soon as possible. Keep up heat and ventilation a couple of weeks, when the tubers (if stored eparate crates) will be dry. After this, ventilators may be closed eep out the cold and the heat may diminish to, say, 60° F. I often the temperature sink as low as 45°, which will do when outside temature is cold. But whenever the weather turns warm, and consently damp, raise the temperature of storage room speedily. The ect is to keep the tubers a little warmer than the surrounding air, hat the moisture from this will not condense on the cooler surface of potato, causing it to "sweat."

farmer who has had extensive experience with this crop in the thwestern part of Arkansas thus states his method of storing sweet atoes in a specially constructed cellar:

ivide inside of cellar into slatted stalls 6 feet wide, 3 to 4 feet p, giving a foot space between stalls. If stalls are one above ther, leave 6-inch space between the stalls. For a large cellar 20 0 by 50 or 75 feet, leave a 3 or 4 foot hall lengthwise through cel- and build bins on each side of hall. * * * Take sweet potas immediately from field to cellar and put in bins 3 or 4 feet deep. ground is wet, sun awhile so that the dirt will slip from the potas. * * * Put nothing around, over, or under them. Leave free air. * * * Every night or day that the thermometer registers above zero, but mostly at night, if possible, keep all ventilators de open; but should it get above 65° outside, close all ventilators ht, for if you let hot air in your cellar it will condense or cause potas to get wet (sweat). * * * Keep as near 45° or 60° inside as ssible. But be sure never to have any part of this cellar stand open en the air outside is 15° warmer than inside. This hot air not being owed to strike the cool potatoes or walls and condensing is the whole ret in keeping them. Cool or cold air will go all through them and ve out all the moisture, but hot air will not.

Sweet-potato houses can be made above ground as well as below, by ng one or more layers of building paper under the siding and ceiling.

From Virginia southward the usual method of keeping sweet potatoes o store them under an open shelter in cone-shaped banks, covered with o 8 inches of straw, hay, or pine needles, and a similar thickness of th on top of that. A ventilator, made of three or four narrow rds perforated with auger holes, should be provided. A few cornlks laid on the potatoes beneath the covering of litter and extend- from the straw floor of the bank to the point of the cone, and also the raised ground below the litter on which the cone is built, improve ventilation and reduce the moisture within the bank. In fair ather the dirt covering may be omitted for a few days, and the ventor, protected from rain, should remain open except during cold ather. In the South sweet-potato houses are also made of logs bed with clay.

Small quantities may be kept for a few months by packing in dry sand and placing in a dry cellar or room. In the South the writer found that sweet potatoes stored several days after digging in large baskets or boxes lined and covered with several thicknesses of newspapers keep fairly well for a short time. In experiments at the South Carolina Experiment Station he found cotton-seed hulls to be a packing material superior to cotton seed, so often used for this purpose. Dry sand was found useful as a covering for sweet potatoes, but less convenient and satisfactory than cotton-seed hulls.

To sum up, sweet potatoes during storage should be kept in a dry atmosphere, with ample ventilation, and a temperature between and 65° F., except during the sweating period, for which time the temperature recommended by those who use artificial heat is about 80° F.

### VARIETIES.

As the sweet potato is not often propagated by seed, there are co paratively few true varieties. Yet about one hundred names, many of them purely local, have been met with in the preparation of this bulletin. The multitude of local names greatly confuses the study of varieties.

The little word "yam" seems to be responsible for considerable confusion in the nomenclature of varieties. Its application is very loose, a variety which in one locality is called a sweet potato being in another designated a yam. There are so-called yams with skin white, yellow, or red, and with flesh either soft and sirupy or dry and starchy. A further objection to the indiscriminate use of the word yam is the fact that it is the correct common name of the *Dios* family of plants, none of which are cultivated in this country except as rare or ornamental plants.

In general terms it may be said that the favorite table varieties a not among the most productive. In variety tests at experiment tions the following varieties gave the largest yields: Providence, Baton Rouge, La., in 1893; Hayman, at Baton Rouge, La., in 1892, a Raleigh, N. C., in 1890; Pumpkin Yam, at Experiment, Ga., and Ba Rouge, La., in 1891; Peabody, at Calhoun, La., in 1892; Shanghai, College Station, Tex., in 1892; Providential, at Geneva, N. Y., in 18 Red Bermuda, at Lincoln, Nebr., in 1889; and Early Golden, at St water, Okla., in 1892. As instances of extremely large yields, may cited the 13 most productive varieties tested at Baton Rouge, La., 1893, of which the yields in bushels per acre were as follows:

| | | | |
|---|---|---|---|
| Providence | 1,072 | Georgia | |
| Shanghai | 758 | Ticotia | |
| Red Nansemond | 717 | Southern Red Yam | |
| Peabody | 696 | Barbados | |
| Norton | 654 | Negro Choker | |
| Hayman | 651 | Spanish Yam | |
| Southern Queen | 640 | | |

These are maximum figures, but they emphasize the difference in the
oductiveness of varieties, for in this same experiment were varieties
lding less than 200 bushels per acre.

Generally the Southern consumer prefers a sugary sweet potato; the
rthern markets demand a starchy root, which, when cooked, will be
her dry. Sugar Yam, Yellow Yam, Spanish Yam, Barbados, Geor-
Yam, Hayman, Vineless, and Pumpkin Yam are among the favorite
le varities in the Southern States. The Yellow Nansemond and
Jersey are standard varieties in Northern markets. Other varie-
s which have been recommended for shipping to Northern cities are
rly Carolina, Red Nansemond, and Red Nose. Among the well-
own early varieties are Early Carolina, Strasburg, Southern Queen,
d Vineless.

Among the most productive varieties, and hence most suitable for
wing as food for live stock, are Providence, Hayman, Norton, Pea-
ly, Red Bermuda, Shanghai, Southern Queen, Negro Choker, and
mpkin Yam.

mong varieties which keep well are Hayman and Southern Queen.
he variety most easily cultivated is Vineless.

FUNGOUS DISEASES.

considerable proportion of the sweet-potato crop is destroyed by
gous diseases.

*lack rot* (*Ceratocystis fimbriata*).—This is regarded as the most
ructive disease of the sweet potato, and is widely spread. It appears
he root in the form of dark
brown or green patches,
h may not be noticed at har-
ng, but which enlarge dur-
torage. These patches are
en areas, resembling spots
ed into the potato with a
l die. The flesh becomes
and bitter, and the diseased
is a source of contamina-
Black rot, unlike soft rot,
dry and inoffensive decay.
cond form of the disease
ks the young sprouts
ing in the propagating
and this "black shank"
consists of lines and spots
ed as stated above. The
se renders the young plants worthless and even accomplishes their
h by girdling. (See fig. 2.)

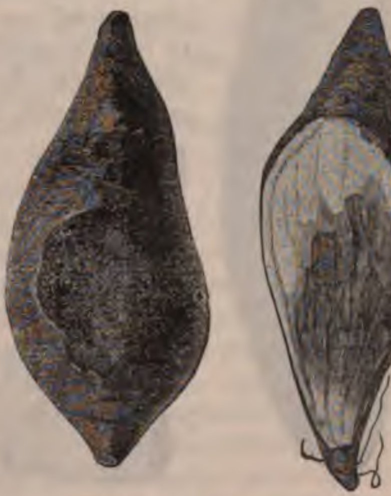


FIG. 2.—Black rot of sweet potato.

a potato with black rot, however slight, is used in the plant bed,

the following spring the sets which grow from it will gen
diseased and will cause the potatoes produced by them to
infected. Another danger is that the earth or manure of t
or field may be contaminated. It is not regarded as safe to pu
roots in the manure heap or in the feed of stock if the manu
used on sweet potatoes. The field on which diseased sweet pot
been grown will probably remain unfit for this crop for seve
Decaying roots should not be left on the soil, but should be
and burned; it is well also to burn the diseased vines. It i
that the germs of this disease may be conveyed by the wind

The fear of getting disease germs in the propagating bed i
sideration that causes some large growers to avoid garde
rich cultivated soil in the plant bed, and to use instead fertil
or woods earth, which are naturally less apt to be infected.
ware Experiment Station deems it practicable to heat to hig
ature the soil of a hotbed warmed by flues so as to destroy
of black rot.

To be sure that no plants affected with "black shank" ar
one grower goes so far as to lift and examine for black rot e
potato before its sprouts are utilized, rejecting sprouts fron
roots. Thus he gets only one crop of
but he regards this course as profitable.

*Soil rot* (*Acrocystis batatas*) is one of
important diseases of the sweet pota
more abundant in a dry year, sometime
almost total loss of the crop, the potato
to reach a marketable size. Soil rot a
young roots when quite small. At the
attack growth ceases and constrictio
After the maturity o
this disease "does no
and destroy the roo
potatoes, if large en
be shipped to marke

Soil rot has not been
to spread by way of t
but only through c
tion of the soil of the
is believed that the
this fungus, which c
to the seed of high
may be blown like
an infected field to one formerly free from the disease. N
is known, but rotation of crops is a preventive measure,
potato occupying the land only once every four or five years

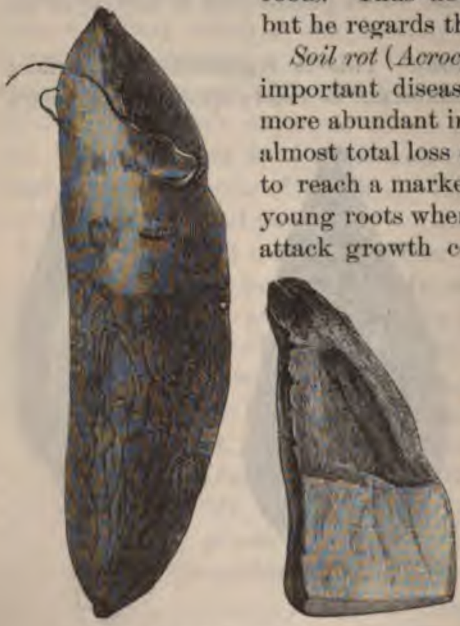


FIG. 3.—Soft rot of sweet potato.

*Soft rot* (*Rhizopus nigricans*) is a soft and putrid decay of the stored ots. (See fig. 3.) Soft rot may not appear on roots when dug; is most abundant a few weeks after harvesting, being most liable occur in the sweating period, when moisture is accumulated on the rface of the roots. The rational preventive treatment for soft rot to burn all diseased potatoes, and dry the good potatoes for a few ys after digging by placing them in a well ventilated and artificially rmed room, with a temperature of 70° to 80° F. Avoid bruising or unding roots in handling. It is important to remove from the pile rotted potatoes, for the disease can be rapidly communicated from ot to root during storage. At the Louisiana Experiment Station sting the stored roots with *fostite* (copper sulphate and soapstone wder) checked the progress of this rot.

*Dry rot* (*Phoma batatæ*).—In dry rot the whole upper part of the tato becomes dry, wrinkled, and pimply, and the entire substance the potato is diseased, being reduced to an almost powdery condin. Such diseased potatoes should be burned.

*White rot*.—The diseased portions of the root have an almost chalky lor and consistency. The first evidence of this disease is a slight pression in the root at the base of a hair-like rootlet.

*Sweet-potato scurf* (*Monilochætes infuscans*) is a brown and rusty ating, frequently appearing on the roots. It causes shrinking, by ich the market value of sweet potatoes is reduced, but it does not sult in decay. It continues to spread on the root after harvesting. a precautionary measure, roots free from scurf should be used in propagating bed.

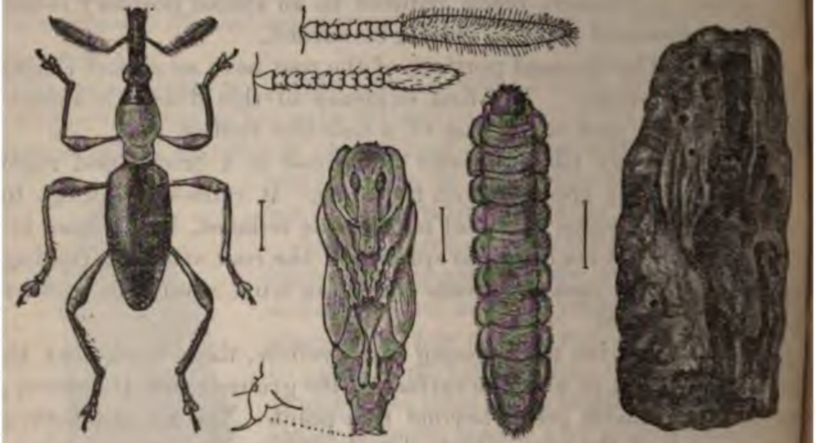
*Stem rot*.—The vine while young turns yellow, then black near the und, and dies at or near the surface of the ground; but, if rooted at ne joint, it remains green beyond that point. The rot also attacks upper part of the root, which, detached from the vines, sends up w shoots late in the season. "The germs are in the soil and inocuon is direct. It is not, therefore, so much a question of healthy nts as a 'healthy soil,' if such an expression is allowable."

Two diseases of the sweet-potato leaf have been described—the leaf ght (*Phyllosticta bataticola*) and the white leaf scab (*Albugo ipomϾaduranæ*). The leaf-blight fungus produces white, dead patches on leaf. The white leaf scab is shown by brown patches on the upper of the leaf and whitish, scab-like spots opposite the brown ches on the underside. As the disease progresses the brown spots ome dark, and the whitish scabs fade out to yellow. The fungus sing this disease grows upon the wild sweet potato or the wild rning glory, sometimes called man-of-the-earth, a weed with massive ts. This weed harbors the fungus during the winter in gall-like argements of the leaf stem, which, breaking up in the spring, ome centers of infection; hence, this weed should be destroyed.

## INSECT ENEMIES.

The following are the most important insects attacking the sweet potato:

*Cutworms.*—It is very desirable to rid the field of cutworms before setting the plants. When danger from this source is apprehended clean culture late in the preceding year should be adopted, and in the spring the field should be plowed early and no green growth should be allowed to appear on the land. A few days before the time for setting the sweet-potato plants thoroughly spray a patch of weeds, grass, or clover with 1 pound of paris green or London purple in 100 gallons of water. Cut the sprayed plat close, and place small heaps of the poisoned food through the field at intervals of 15 to 20 feet each way. Such worms as are present in the field will eat this poisoned vegetation and will thus be destroyed.



G. 4.—The sweet-potato root borer (*Cylas formicarius*). Extreme left-hand figure, adult with enlarged antennæ at right and above. Figure at left center, pupa; at right center, lar extreme right, portion of sweet-potato tuber channeled by borer. All figures except the siderably enlarged; natural sizes indicated by hair lines. (Drawn by L. Sullivan.)

*Flea-beetles.*—These tiny insects are most injurious to the sweet pot soon after the plants are set in the field. The New Jersey Experim Station recommends that the sets as soon as drawn be dipped i water in which 1 pound of paris green or London purple and 1 p f lime have been mixed in every 175 gallons of water, or in a decoc f tobacco. This is expected to protect the young plants until they h tarted growth, after which they can better withstand insect attac

*Tortoise beetles* (*Cassidæ*).—These "golden bugs," both in the for eetles and in their larval state as spiny worms, eat the leaves of oung sweet-potato plant. Spraying as soon as the plants are w ooted and again a week later with 1 pound of paris green or Lond urple and 1 pound of lime to 175 gallons of water is recommended.

*Sweet-potato sawflies* (*Schizocerus* spp.).—Should the larvæ of sawflies become troublesome on sweet-potato vines, spraying with the formula given in paragraph on flea-beetles should be tried.

*Sweet-potato root beetle* (*Cylas formicarius*).—This subtropical insect has honeycombed sweet-potato roots in some parts of Florida, Louisiana, and Texas. It is the most serious enemy to the sweet-potato crop n regions where it occurs and seems to be extending its range northward. Pulling up and burning all affected roots and vines is the only means at present known for repressing this pest. Sweet-potato growers n regions which this insect has not reached should be on the lookout or it and should especially examine with great care all sweet potatoes rought from Florida, Texas, or Louisiana. The accompanying illustration (fig. 4), drawn under the supervision of the Entomologist of this Department, is introduced to familiarize growers with its appearance. The infested tubers become thoroughly channeled with the larval burrows, and eventually shrivel up and decay. The colors of the beetle re red and black.

*Sweet-potato hawk moth* (*Macrosila cingulata*).—The larva of this nsect is known to growers as the "horn worm." Its large size renders it easy to hand pick, and it is also readily destroyed by the paris-green treatment.

## USES OF SWEET POTATOES.

### AS A TABLE VEGETABLE.

The most important use of the sweet potato is as human food, the ots being baked, boiled, or otherwise prepared. It contains more ry matter and more starchy and sugary material, but less nitrogenous utrients than the Irish potato. A dietary in which it enters largely ould also include beans, peas, lean meat, eggs, or other highly nitrogenous food.

Uncooked sweet potatoes may be sliced and then dried either in the n or in evaporators. They are prepared for the table by soaking and king. Dried sweet potatoes were exhibited among the products of pan at the Columbian Exposition. Their preparation is described follows:

"Cleanly washed potatoes are placed in a suitable basket and mersed in boiling water for a short time; when taken out of the sket they are cut into thin slices and spread over mats and exposed the sun for two or three days. In order to make a superior quality skin of the potato is peeled off before slicing."

In some countries the young leaves and tender sprouts of the sweet-potato plant are prepared and eaten like spinach.

### CANNING SWEET POTATOES.

Within recent years sweet potatoes have been canned in a few localities. In 1893 a factory in Mississippi canned about 1,000 bushels, using

3-pound cans, which sold in Chicago at 95 cents per dozen delivered. A bushel of sweet potatoes was sufficient for 15 cans. Farmers were paid 40 cents per bushel. This firm expected to can about 8,000 bushels of sweet potatoes in 1894.

Should the canneries now engaged in packing sweet potatoes succeed in creating a large demand for this product, sweet potatoes would become a profitable cash crop in many localities where they are now unsalable. The canneries would also be benefited, not only in the direct profits from canning sweet potatoes, but in being able to operate during a greater number of months, the sweet-potato crop coming in after most vegetables and fruits have passed out of season.

### SWEET POTATOES AS FOOD FOR STOCK.

Only in localities favored with transportation facilities and good markets is the sweet potato a sale crop. But as a food for stock it should be extensively grown in regions adapted to it. The roots have been successfully fed to hogs, cattle, and horses. For cattle and horses it is better to slice the roots. Of all classes of stock, hogs can be used to consume sweet potatoes to best advantage, since they do their own digging.

The following table gives the average composition of 7 varieties of sweet potatoes, the figures for each variety having been compiled from analyses of roots grown in three or four States.

*Average composition of varieties of sweet potatoes.*

| Variety. | Water. | Ash. | Protein. | Fiber. | Nitrogen-free extract. | Fat. | Total dry matter. |
|---|---|---|---|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Jersey (including Early Jersey, New Jersey, and Yellow Jersey) | 69.52 | 1.09 | 2.28 | 1.23 | 24.59 | 0.63 | 29.82 |
| Peabody (including Early Peabody) | 73.11 | 1.11 | 1.81 | 1.22 | 22.73 | .59 | 27.46 |
| Pumpkin | 70.09 | 1.18 | 1.94 | 1.22 | 24.06 | .66 | 29.06 |
| Red Bermuda | 72.30 | 1.11 | 1.77 | .86 | 23.24 | .55 | 27.53 |
| Southern Queen | 67.17 | 1.11 | 1.38 | 1.11 | 28.46 | .43 | 32.49 |
| Shanghai | 69.32 | 1.29 | 1.88 | .99 | 25.75 | .77 | 30.68 |
| Vineless (including Bunch Yam and Early Bunch Yam) | 70.24 | 1.10 | 2.47 | 1.06 | 24.29 | .85 | 29.76 |

We find from the above table that 100 pounds of sweet-potato roots contain 69.32 to 73.11 pounds of water, 1.09 to 1.29 pounds of ash, 1.38 to 2.47 pounds of protein (the so-called flesh formers, the most costly of all food constituents), 0.86 to 1.23 pounds of fiber, 22.73 to 28.46 pounds of nitrogen-free extract (starch, sugar, gums, etc.), and 0.43 to 0.85 pounds of fat, or a total of 27.46 to 32.49 pounds of dry matter. If we judged of food value by the amount of dry matter we should pronounce Southern Queen the most nutritious variety, but its advantage in dry matter is counterbalanced by its low content of protein, only 1.38 per cent. This variety especially, and indeed all sweet potatoes, are too deficient in protein to constitute a perfect food when used alone. This deficiency may be supplied by feeding, in connection with sweet-potato roots, foods rich in protein, such as clover, peas, cotton-seed meal, middlings, and skim milk. Since the differences in the nutritive value of the above varieties are not great, the choice of varieties for stock food may be based on productiveness alone (see p. 20).

A clear conception of the food value of sweet potatoes may be acquired by comparing the composition of these roots with that of corn.

*Relative food values of corn and sweet potatoes.*

| | Dry matter. | Protein. | Nitrogen-free extract and fat. |
|---|---|---|---|
| | *Pounds.* | *Pounds.* | *Pounds.* |
| 100 pounds corn contain | 89.1 | 10.5 | 75 |
| 300 pounds sweet potatoes contain | 86.7 | 4.5 | 75.3 |

Thus 3 pounds of sweet potatoes afford almost as much dry matter, quite as much carbonaceous material, but less than half as much protein as is contained in 1 pound of corn. By using one-half pound of cotton-seed meal or 1 pound of cowpeas (seed) for every 10 pounds of sweet potatoes this deficiency in protein is fully supplied. I can find no record of digestion experiments with sweet potatoes.

On many an acre of rather poor, sandy land where corn is now grown it would be advantageous to substitute sweet potatoes intended for stock food, for frequently such soils are capable of producing 5 to 8 times as much sweet potatoes as corn.

### THE VINES AS FOOD FOR STOCK.

Sweet-potato vines are usually left to decay in the field where they are grown. However, they may be utilized as food for cattle. An analysis of very succulent sweet-potato vines grown in Texas showed them to be practically identical in chemical composition with succulent cowpea vines, of which the feeding value is well established.

Vines of 5 varieties were analyzed at the Georgia Station, and showed considerable differences in composition. It is claimed that the vines of the so-called Vineless variety, which stand up well, can be cut with a mowing machine, but to permit of this it will be necessary to cultivate nearly level. The vines are better suited for feeding green than for curing into hay. In the silo they are said to become slimy. The writer weighed a heavy crop of green vines, and found that the weight was 5½ tons per acre. At the Texas Experiment Station the yield of green vines was much greater.

### COST OF PRODUCTION.

Sweet-potato growers in a number of States furnished the data used below in estimating the cost of growing sweet potatoes. Rent, cost of fertilizers, and cost of shipping are not included in the following statements.

Averaging the returns of several experienced growers in New Jersey, we have the following figures, which may be taken as representative of the cost (less fertilizers and rent) of growing an acre of sweet potatoes in New Jersey, Delaware. and the tide-water counties of Virginia: Sets grown or purchased, $5; preparation of the soil, $1.97; transplanting (with wooden tongs), $2.12; horse cultivation, $1.62; hoeing and other hand work, $3.75; harvesting, $6.50; total, $20.96. To this, in addition to rent or interest, must be added $10 to $40 per acre for fertilizers or stable manure.

The following figures are averages from six statements selected from among those sent in by growers in the Southern States, and give the cost of cultivating an acre: Seed potatoes for sets or vine cuttings, $1.98; preparation of the soil, $2.79; transplanting sets or cuttings, $2.91; horse cultivation, $1.87; hoeing and other hand work, $1.62; harvesting, $5.66; total, $16.83. The figures used in making up these averages vary between the following limits: Seed potatoes, $1.25 to $4.75; preparation of land, $1.25 to $4.50; transplanting, $1 (doubtless for vine cuttings) to $6; horse cultivation, $1 to $3; hoeing, etc., 50 cents to $3.50, and harvesting, $3 to $8.

Numerous other estimates of the cost of growing an acre of sweet potatoes in the Southern States approximate closely to $16.83, and confirm the correctness of this figure. Returns from this section of the country indicate that this crop is too frequently left without manuring.

As regards cost per bushel, an Arkansas horticulturist, who grows sweet potatoes on a large scale, places the cost of a bushel of sweet potatoes in the ground at 4½ to 11½ cents when the yield is 150 to 300 bushels per acre; digging and storing cost him 2½ to 3½ cents, making a total cost of 7 to 15 cents per bushel in the cellar. From Illinois and from Georgia come statements that 20 cents is the cost of growing and harvesting a bushel.

When we come to consider selling price and profits we find difficulty in generalizing, on account of the wide fluctuations to which the price of this vegetable is subject in the large cities, and to the fact that over a great extent of country there is practically no market, except for small quantities.

The principal markets for Eastern growers are New York, Baltimore, Philadelphia, Boston, and Providence, and in spite of wide fluctuations in price the sweet-potato crop is usually profitable in localities favored with cheap transportation facilities to these cities. During the period from July 15 to August 15 there is only a limited supply of sweet potatoes in Northern markets, and potatoes of good quality find a ready sale at relatively high prices. The sweet potato is a profitable crop where local sales can be effected. In localities remote from mar-ets the profit in growing this crop on a large scale must come from onverting sweet potatoes into pork or some other valuable animal roduct. As a partial substitute for corn in the food of hogs the weet potato should be extensively used in localities where, on account f poor, sandy soil, corn does not give large yields.

## SUMMARY.

The sweet potato is most commonly propagated by means of the buds or shoots from the roots, which are called sets. The roots are planted in hotbeds and the sets which develop are removed and transplanted in the field. This crop is sometimes grown from vine cuttings.

For lightening the labor of transplanting sweet-potato sets, wooden tongs, or transplanters drawn by horses, may be used.

In experiments at the Alabama Station cuttings gave a slightly larger yield than sets; at the Louisiana Station sets produced the larger crop. In Louisiana vine cuttings 16 to 24 inches long gave larger yields than shorter cuttings. It is generally regarded as unprofitable to move sweet-potato vines after last cultivation.

One hundred and eighty-five bushels (10,000 pounds) of sweet potato roots remove from the soil 23 pounds of nitrogen, 10 pounds of phosphoric acid, and 50 pounds of potash; this is equal to the nitrogen in about 150 pounds of nitrate of soda, to the phosphoric acid in about 90 pounds of acid phosphate (superphosphate), and to the potash in about 370 pounds of kainit.

A fertilizer containing nitrogen, phosphoric acid, and potash is most certain to afford a large yield. Of these constituents potash is most important and should be supplied in largest quantity.

Much confusion exists in the names applied to varieties of sweet potatoes. Generally the Southern consumer prefers a sugary sweet potato, such as Sugar Yam, Yellow Yam, and Barbados. Northern markets demand a starchy, rather dry root, such as Big Stem Jersey and Nansemond. As food for live stock the most productive varieties should be grown, as Providence, Shanghai, Hayman, Red Bermuda, and Southern Queen.

Early digging of sweet potatoes considerably reduces the yield, but is sometimes justifiable by reason of the higher prices prevailing earlier in the season.

Sweet potatoes are more easily brusied than mature Irish potatoes and require very careful handling.

Sweet potatoes are successfully kept by maintaining a temperature of about 75° F. for a week or two after digging, then lowering the temperature and keeping it through the winter at 50° to 60° F. The atmosphere of the storage room should be kept dry. The condensation of moisture on the roots affords conditions favorable to decay.

The use of sound seed sweet potatoes and rotation of crops are the best means of avoiding fungous diseases and insects, which sometimes seriously injure the sweet-potato crop.

A little over two-thirds of the weight of sweet-potato roots is water. Three pounds of sweet potatoe afford as much dry matter, but less than half as much protein (the so-called flesh formers), as 1 pound of corn. Sweet potatoes on sandy soil generally yield more dry matter (food) per acre than corn, and in many cases may be advantageously substituted for this crop on land too sandy and poor to afford a profitable yield of corn, and may be used as a food for hogs and other live stock.

The cost (exclusive of rent and fertilizers) of growing and harvesting an acre of sweet potatoes varies greatly, and is estimated to be, on an average, not far from $20. In spite of wide fluctuations in price, the sweet-potato crop is usually profitable in localities favored with cheap transportation facilities to large cities. It is also a profitable crop where local sales can be effected. In localities remote from markets the profit in growing this crop on a large scale must come from converting sweet potatoes into pork or some other valuable animal product.

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The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to Senators, Representatives, and Delegates in Congress or to the Secretary of Agriculture, Washington, D. C.:

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120. The Principal Insects Affecting the Tobacco Plant.

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U. S. DEPARTMENT OF AGRICULTURE.

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FARMERS' BULLETIN No. 28.

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# EEDS; AND HOW TO KILL THEM.

LYSTER H. DEWEY,
ASSISTANT BOTANIST.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1895.

# LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF BOTANY,
*Washington, D. C., April 12, 1895.*

IR: I have the honor to transmit herewith for publication as a rmers' Bulletin an illustrated report entitled "Weeds; and How to Them," by Mr. Lyster H. Dewey, Assistant Botanist. The value the principal field crops of the United States for the year 1894, luding corn, wheat, oats, rye, barley, buckwheat, tobacco, potatoes, hay, according to official statistical returns, is $1,630,873,795. estimate does not cover cotton, pasturage, fruit, garden truck, or agricultural products, all of which are of immense commercial ortance. The direct loss in crops, the damage to machinery and k, and the decrease in value of land due to weeds, amount, without tion, to tens of millions of dollars each year—a loss sustained ost wholly by the farmers of the nation. This brief bulletin con- simple and valuable directions for weed eradication, and in view he enormous interests concerned it is hoped that these methods may be incorporated in our systems of practical farming.

Respectfully,

FREDERICK V. COVILLE,
*Botanist.*

on. J. STERLING MORTON,
*Secretary of Agriculture.*

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# WEEDS: AND HOW TO KILL T

## INTRODUCTION.

During the season of 1894, which was remarkable fo drought, the ordinary farm crops were checked in their g weeds became more conspicuous than usual. This fact, the attention attracted by certain species recently in awakened particular interest in the subject of weed er there has been an enlarged demand for accurate knowle to injurious weeds. This fact has been amply recognized States Department of Agriculture, and the time and pai the study and investigation of weeds in its Division of been greatly increased in late years, while its efforts have to meet the growing demand for accurate information by the frequent publication of bulletins and circulars. cations have also been issued from the experiment static agricultural papers have given the subject of weeds consi in their columns.

For the complete eradication of a noxious plant, the seeds must be prevented, and if the plant is a biennial the rootstock must be killed. The processes by which se may be prevented or rootstocks killed are comparatively cases, and in no case are they impracticable. It would se at first thought that the best processes of weed eradicatio and practiced with reasonable fidelity the complete eradi of the farmer's worst enemies might be accomplished. I of weeds which have already become abundant and wide the conditions under which many of them occur are such ing community regards their extermination as impossibl only hope for their reduction to a state of comparative species newly introduced, however, might doubtless eradicated if taken in time. If the farmer on whose land thistles grew in 1873 had known the evil character of spent a few hours destroying them in his flax field, the have been completely annihilated in this country and mill years of labor saved.

The same might doubtless be said, were their histories ving devil weed of northern New York, the Pa

Florida, Georgia, and the Carolinas, the prickly lettuce of the Northern States, and many others. This emphasizes the necessity that each landowner should be on the watch for new plants and learn their character, if possible, before they become established and assert themselves as aggressive weeds on his farm. This eradication of a species on its first appearance in a limited area forms practically the only possible method of complete and final extermination, unless public sentiment shall be aroused to the point of a more vigorous and universal destruction of weeds than has heretofore been practiced. Unless strongly supported and enforced by the people directly interested, laws for the complete extermination of weeds are of little avail, and in most cases thus far they have been found ineffectual, as is proved by the abundant crops, growing year after year, of Canada thistles in Pennsylvania, Ohio, and Michigan, of wild carrots in Connecticut, and of cockleburs and sunflowers in Kansas.

If weeds can not be completely exterminated they may be brought under subjection, and in restricted localities this subjection may approach so near to extermination as to prevent any material damage without requiring appreciable extra labor. This is almost the ideal condition for a farm so far as weeds are concerned. There are all gradations from this condition to that of the farm so weedy that a profitable crop can not be raised and that no one will buy the land at any good price unless he has some assurance that wild onion, penny cress, horse nettle, Canada thistle, or quack grass can be killed or controlled. Any species of weeds can be subdued and controlled within the limits of an ordinary farm, and unless the value of the land is low from other causes this may be profitably undertaken.

## GENERAL METHODS OF ERADICATING WEEDS.

If the weed, like many of our most abundant kinds, is an annual, reproducing itself from the seeds only and dying root and branch each year, it may be subjected by preventing seed production. The seeds of many annuals retain their vitality for several years, so that if they once become abundant in the soil they are likely to germinate at irregular intervals, and thus cause trouble for a long time, even though no fresh seed is introduced. In this case merely preventing the production of seed will gradually reduce the quantity of weeds and will prevent any further spreading.

For permanent pastures, lawns, and roadsides this is often the most practical method, and it is quite sufficient if persistently followed. In cultivated fields the land thus seeded should first be burned over to destroy as many as possible of the seeds on the surface. It may then be plowed shallow, so as not to bury the remaining seeds too deeply in the soil. The succeeding cultivation, not deeper than the plowing, will induce the germination of seeds in this layer of soil and kill the seedlings as they appear. The land may then be plowed deeper and the cultivation repeated until the weed seeds are pretty thoroughly leared out to as great a depth as the plow ever reaches. Below that depth—8 to 10 inches—very few weed seeds can germinate and push a shoot to the surface. A thousand young seedlings may be destroyed n this manner by the cultivator with less effort than a single mature plant can be destroyed, and every seedling killed means one less weed seed in the soil. Barren summer-fallowing is often practiced to clear out weedy land by the method just described; but usually corn, potatoes, rape, cabbages, or beets may better be grown, giving a profitable return for the extra cultivation. The best results can be obtained, of course, with crops that allow cultivation during the greater part of the season, and that do not shade the soil too much, as the direct rays of the sun heating the surface of the soil aid materially in the germination of many seeds.

As annual weeds usually thrive best in soil that has been broken but is not occupied, it is evident that broken land should not be permitted to remain idle. Abundant crops of annual weed seeds are matured every fall on potato and corn land and in stubble fields, where a profitable crop of crimson clover or winter oats or rye might have been grown. A little grass seed raked in on bare hillsides will often keep down annual weeds and will at the same time prevent washing. Mowing the roadside two or three times during the summer will subdue the dog fennel and ragweed. Mowing the stubble about two weeks after harvest in grainfields that have been seeded to grass or clover will check the annual weeds and at the same time produce a mulch that is very beneficial to the seeding during the August drought.

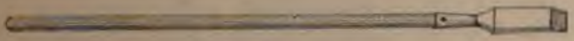

Fig. 1.—Spud.

Biennials, such as burdock, wild carrot, and bull thistle, store up nourishment in thickened roots during the first year of growth and during the second year they produce seed and die. Many species which are ordinarily true biennials will live three years, or possibly longer if seed production is prevented by mowing or cutting the stem above the crown of the root. In fact, mowing or cutting off the main stem often induces it to branch out at the base and send up several stalks in place of the one. Cutting the roots below the crown usually kills them. If this work is to be done by hand with a hoe, grub hoe, or spud, as is often the case with bull thistles on new ground, it can be done most effectively and with least labor in the fall, during the first year of growth. The stools or rosettes of leaves, close to the ground, often give little suggestion of the prominent seed stalk to be grown the following year; but they are sufficient to indicate to the observing eye the presence of weeds. The root at this time is more tender, and hence more easily cut than in the mature plant, and one does not have to strike so deep to be sure of killing it. In sod ground a spud—a tool like a chisel on the end of a fork handle (fig. 1)—may be used to much better advantage than a hoe for cutting thickened roots b surface.

Biennial weeds are readily killed by cultivation such as is hoed crops, and the seeds may be cleaned out of the land method. The weeds of this class are usually most abundan pastures, along roadsides, and in waste places where the soil i disturbed. The weeds must be destroyed in these places if of clearing the seed out of cultivated fields is to be made effec

Perennial weeds reproduce themselves by seeds and also p by some form of perennial underground stem, as the roots Canada thistle and couch grass, the corm or solid bulb, of the n and chufa, and the bulb of the wild onion. A few plants so classed as noxious weeds have runners above ground, as Bermu and cinquefoil. To destroy perennial weeds, seed production prevented and the underground portion must be killed. Seed tion may be prevented by mowing when the first flower buds the same as in the case of annuals or biennials. The best met killing the rootstocks vary considerably according to the soil, character of the different weeds, and the size of the patch quantity to be killed. In general, however, the following pr apply:

1. The rootstocks may be dug up and removed, a remedy tha practically applied only in small areas.

2. Salt, coal oil, or strong acid applied so as to come in conta the freshly cut roots or rootstocks destroys them for some d from the point of contact. Crude sulphuric acid is probably th effective of comparatively inexpensive materials that can be us this purpose, but its strong corrosive properties render it dan to handle.

3. Rootstocks may be starved to death by preventing any de ment of green leaves or other parts above ground. This may be eff by building straw stacks over small patches, by persistent, tho cultivation in fields, by the use of the hoe or spud in waste places by salting the plants and turning on sheep in permanent pastures

4. The plants may usually be smothered by dense sod-for grasses or by a crop like clover or millet that will exclude the ligh

5. Most rootstocks are readily destroyed by exposing them t direct action of the sun during the summer drought, or to the action of the frost in winter. In this way plowing, for example, be effective.

6. Any cultivation which merely breaks up the rootstocks and them in the ground, especially during wet weather, aids in their di tion and multiplication, and is worse than useless, unless the c tion is continued so as to prevent any growth above ground. P and fitting corn ground in April and May, and cultivating at in until the last of June, then leaving the land uncultivated dur

remainder of the season, is one of the best methods that could be pursued to encourage the growth of couch grass, Johnson grass, and many other perennial weeds.

### WEEDS ATTRACTING ESPECIAL ATTENTION DURING 1894.

The influence of the Russian thistle agitation is plainly manifest in the attention given to certain weeds during the past season. Nearly one-half of those received at the United States Department of Agriculture with requests for naming and information belong to species which are more or less prickly, and many of them have been mistaken for the Russian thistle. While but few complaints have been received in regard to the older well-known weeds, such as ragweed, dog fennel, and shepherd's purse, it is not to be supposed that these are becoming less abundant or less troublesome. People are generally familiar with these common weeds, too often so familiar that the weeds have come to be accepted as a matter of course and a necessary evil. Complaints about Canada thistle, couch grass, and Johnson grass indicate that these weeds, even when well known, can not be disregarded; but in general it is the new weed coming as an added evil that attracts attention.

Aside from the Russian thistle, the following ten species of weeds in the order given have received the most notice during 1894, according to the reports received at the United States Department of Agriculture:

Pricky lettuce (*Lactuca scariola*).
Bracted plantain (*Plantago aristata*).
Horse nettle (*Solanum carolinense*).
Buffalo bur (*Solanum rostratum*).
Spiny amaranth (*Amaranthus spinosus*).
Dagger cocklebur (*Xanthium spinosum*).
Chondrilla (*Chondrilla juncea*).
Wild carrot (*Daucus carota*).
Wild oat (*Avena fatua*).
False flax (*Camelina sativa*).

#### PRICKLY LETTUCE (*Lactuca scariola*).

The prickly lettuce is also known by the common names milk thistle, English thistle, and compass plant. During the past season it has been mistaken for Russian thistle in many localities. It is a native of Europe. The first record we have of it in this country is in the fifth edition of Gray's Manual (1868), where the locality is given as "waste grounds and roadsides, Cambridge, Mass." About ten years later it was observed in the region of the Great Lakes, and now it has become widely distributed throughout nearly all the States from Massachusetts to Virginia and westward to the Missouri River, and has crossed the mountains to Idaho, Oregon, and Washington. It is most abundant and troublesome in the States bordering on the Ohio River and the Great Lakes.

The prickly lettuce is closely related to the common garden lettuce, which it resembles in the seed-bearing stage (fig. 2, *a*). It is an annual, sometimes doubtless a winter annual, partaking of the character of a biennial. The stem, smooth or with small scattered prickles, rises to a height of 2 to 6 feet, bearing a few lateral branches and a large open panicle of flowers. The flowers are small, one-fourth to one-half inch in [illegible] inconspicuous, as only a few are open at a time. The plant begins to bloom in July and produces a few blossoms [illegible] until killed by the frost. The seed, or strictly speaking the akene—the seed with the close-fitting case which contains it—is dark [illegible] color, flattened, between oblong and lance-shaped [illegible] sixth of an inch long and one-fourth as broad. On [illegible] there are 5 or 6 ridges lengthwise, which are [illegible]. At the [illegible] a slender, thread-like beak, nearly as long as the body of the akene, bearing a tuft of fine white hairs about as long as itself (fig. 2, c). In the fruiting stage the tufts of the 10 to 15 seeds which grow in one head spread out so as to form a white, gauzy ball of down, like that of the dandelion, but smaller and less dense. A single average plant has been estimated to bear more than 8,000 seeds. The leaves are oblong and without stalk, the blade clasping the main stem by a base with two ears. They are prickly along the wavy margins and along the midrib on the back (fig. 2, [illegible]). The principal leaves on the stem have the unusual habit of twisting so that the upper part of the blade becomes vertical. They also point north and south, hence the name compass plant. The white, milky juice has suggested the name milk thistle. Both of these names [illegible] they are properly applied to [illegible]

[illegible] prickly lettuce is very troublesome in [illegible]. Clover intended for a seed crop is [illegible] spring grain crops suffer more [illegible]

[illegible] the young prickly lettuce, and in [illegible] have been found very effective in keeping [illegible] and where thorough cultivation [illegible] the plants as they first begin to blossom will prevent seeding and eventually subdue them. Thorough cultivation with a hoed crop, by means of which the seed in the soil may be induced to germinate, will be found most effective. The first plowing should be shallow, so as not to bury the seeds too deep. Under no circumstances should the mature seed-bearing plants be plowed under, as that would only fill the soil with seeds buried at different depths to be brought under conditions favorable for germination at intervals for several years. Mature plants should be mowed and burned before plowing. The seed appears as an impurity in clover, millet, and the heavier grass seeds, and the plant is doubtless most frequently introduced by this means. As the seed may be carried a long distance by the wind, the plants must be cleared out of fence rows, waste land, and roadsides.

### BRACTED PLANTAIN (*Plantago aristata*).

This plant, although a native of the Mississippi Valley and well known to botanists since the beginning of the present century, is practically new as a weed. In a very few instances its seeds have been mentioned as a minor impurity in clover seed, but it is not named in any of the numerous lists of weeds of the United States. During the past season it has appeared in abundance in meadows, pastures, and lawns in many localities from Maryland to Illinois. Although generally reported as new, it had doubtless existed before in small quantity and with less robust habit in many of these places. In some instances, however, it is known to have been introduced during the past season in lawn grass seed.

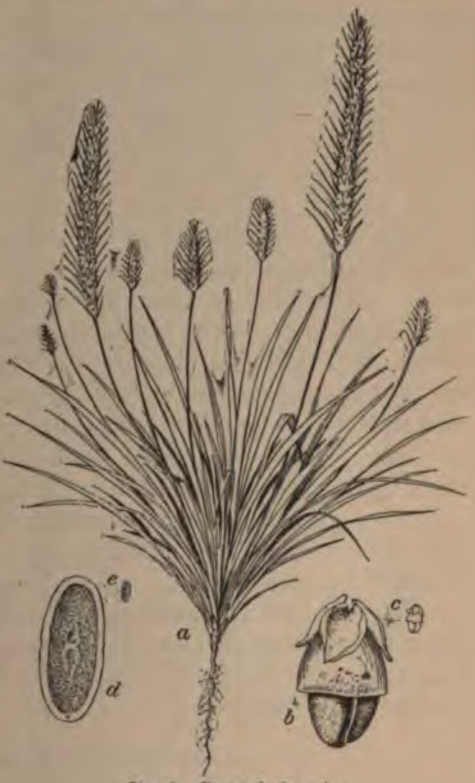

Fig. 3.—Bracted plantain.

The bracted plantain is an annual, sometimes a winter annual, and in some cases the roots are apparently perennial. The leaves are not killed even by severe frosts. It is closely related to the lance-leafed plantain, or rib grass, and to the woolly plantain. The leaves, appearing almost like a tuft of rather thick, dark-green grass leaves, spring from the apex of a somewhat thickened root (fig. 3, *a*). The seed-bearing stems, 5 to 12 inches in height and numbering 5 to 25 on each plant, as in other plantains, are leafless and naked near the base. At first the flower spike is contracted and short, but at maturity it is 2 to 5 inches long and crowded with small flowers (fig. 3, *a*). Below each flower is a narrow green bract one-half to one inch long, giving the flower spike a plume-like appearance. Each flower produces two seeds in an egg-shaped capsule which opens transversely, the dome-shaped lid with the persistent, papery corolla lobes falling away with the two seeds hanging in it (fig. 3, *b*, *c*). This kind of parachute enables the seeds to be carried a short distance by the wind. They usually fall near the parent plant, hence after the first introduction the bracted plantain grows in dense colonies, covering the ground so thickly as to choke out all other vegetation. An average plant produces about 15 flower spikes, and an average spike bears about 100 flowers or 200 seeds, making a total of about 3,000 seeds to the plant. The seeds are dark brown or nearly black, oblong, concavo-convex, rounded at the ends, and about one-twelfth of an inch long (fig. 3, *d*, *e*). They are most likely to be found as an impurity in clover seed and the heavier grass seeds.

The bracted plantain is so low and inconspicuous and its leaves are so much like those of grass that it is not easily discernible until the flower spikes appear. Hand pulling and burning is perhaps one of the best remedies where the plants are not too abundant. If the land has become thoroughly seeded a series of hoed crops will probably be necessary to clear it out. In permanent pasture, mowing the plants as the seed stalks first appear will keep them in subjection. The mowing will have to be repeated several times, however, as the bracted plantain sends up seed stalks from May until November.

The reports concerning this plant during the past season indicate that, if unchecked, it is likely to prove as troublesome as the rib grass which has become so widely distributed, chiefly in clover seed. The seeds of the bracted plantain are of nearly the same size and shape as those of the rib grass, and as they ripen throughout the same season—June to November—they are just as likely to be harvested and thrashed with the clover seed.

### HORSE NETTLE (*Solanum carolinense*).

The horse nettle is native in the southeastern part of the United States, as its specific name indicates. It is now found in nearly all of the States east of the Missouri River, and is slowly increasing its territory. As the seeds are seldom found as impurities in commercial seeds, and as they have no special adaptation to aid in distribution except that the berries are sometimes eaten by birds, the horse nettle spreads rather slowly. When it has once obtained a foothold, however, it ranks among the worst weeds of this country as regards difficulty of eradication.

closely related to the common potato, which it much resembles
white or purple flowers and yellow berries. The plants are 6 to
hes in height, loosely branching, rough, with short, stiff hairs, and
with yellow prickles (fig. 4, *a*). The leaves are oblong and irregu-
obed like those of the white oak. The midrib and larger veins
prickles like those of the stem, but smaller. The plant is repro-
by the seeds (fig. 4, *c*, *d*), which are borne in the berries, and it is
lantly propagated, also, by slender perennial rootstocks.

horse nettle is not eaten by any kind of farm stock, even when
and made into hay,
avoided on account of
arp prickles and rough
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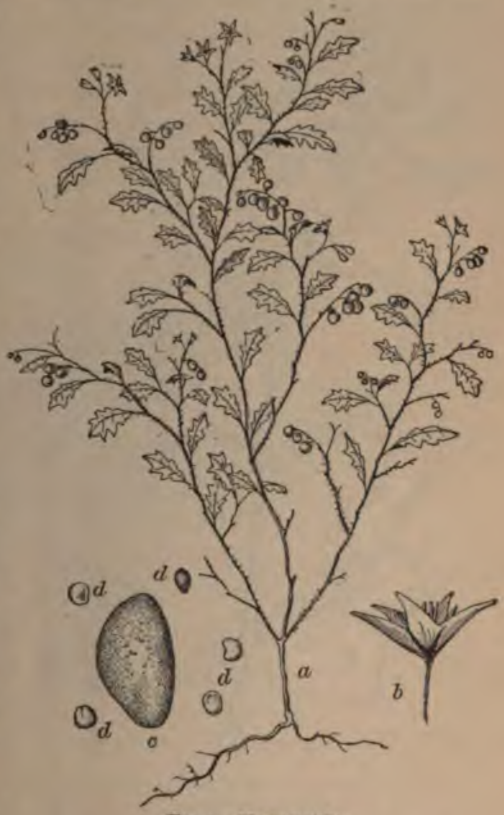

FIG. 4.—Horse nettle.

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e. Clean cultivation
grubbing or spudding sufficient to prevent any development above
nd will starve out the rootstocks. Oats, barley, or millet sown
ly on well-tilled land will weaken the rootstocks, preventing much
th above ground. Immediately after these crops are harvested the
may be plowed and then harrowed frequently until time for sowing
son clover or winter rye. This will induce the germination of weed
, and at the same time expose some of the rootstocks to be killed
e sun. Crimson clover, hairy vetch, rye, or winter oats may be
to choke down the growth of horse nettle and other weeds during

the fall and early spring, to furnish winter pasturage, and then to be plowed under as a green fertilizer. A hoed crop following, if kept well cultivated, will clear out most of the remaining weeds. The plowshare used in these operations should be kept sharp, so as to cut a clean furrow, otherwise the rootstocks are likely to be dragged and scattered about the field.

### BUFFALO BUR (*Solanum rostratum*).

This plant is also native in this country, originally growing on the western plains, close to the mountains, from Mexico northward. It was doubtless spread to some extent by the buffaloes, as it has been found along the buffalo wallows. While the horse nettle has been slowly traveling westward the buffalo bur has been working eastward, until it is now found in many States east of the Mississippi River, and has even crossed the ocean, threatening to become a troublesome weed in Germany. It is related to the potato, and closely resembles the horse nettle, but its spines are stouter and more abundant and its flowers are yellow. Instead of the smooth, yellow berries of the horse nettle and potato, moreover, it has spiny burs, somewhat resembling those of the burdock at first, but developing at maturity into nearly spherical, spiny balls, filled with black, irregular seeds (fig. 5, *c*, *d*). These burs, becoming attached to passing animals, are readily scattered. The plant has a lighter, more bushy habit than the horse nettle, and is often blown about as a tumbleweed in the prairie region.

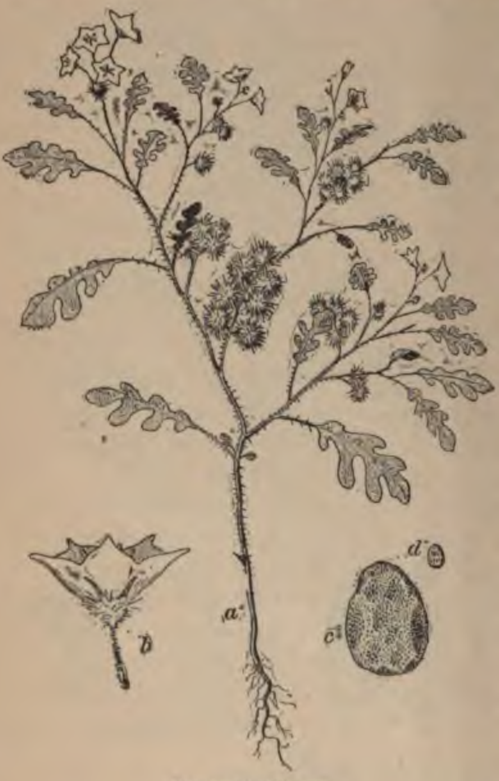

FIG. 5.—Buffalo bur.

It is an annual, easily subdued by preventing the production of seeds. This may be done by mowing as often as the yellow blossoms appear. The seeds are less abundant than those of most of the bad annual weeds, and they are not often ripe, at least in the northern part of its range, until after the hurrying work of harvest is over. The buffalo bur is seldom troublesome in fields where thorough cultivation is practiced, The seeds may be expected as impurities in alfalfa and clover seed grown in the West. So far as known, however, in the East this weed has appeared in waste places in cities and towns and has spread thence to the surrounding farms.

In this respect the buffalo bur is typical of a large number of introduced weeds, which are neglected on the waste land in villages and cities where they do no direct and manifest injury. The Canada thistle and spiny amaranth are growing on many vacant lots in Washington. The prickly lettuce first became abundant in Michigan and Ohio in the cities of Detroit and Toledo. The Russian thistle is now growing unchecked, save by the occasional botanical collector, in many localities in and about Chicago. Similar instances might be multiplied; in fact, probably the majority of the cities and towns of this country are harboring noxious weeds which should be destroyed in simple justice to the farming communities which aid most directly in supporting the prosperity of these towns.

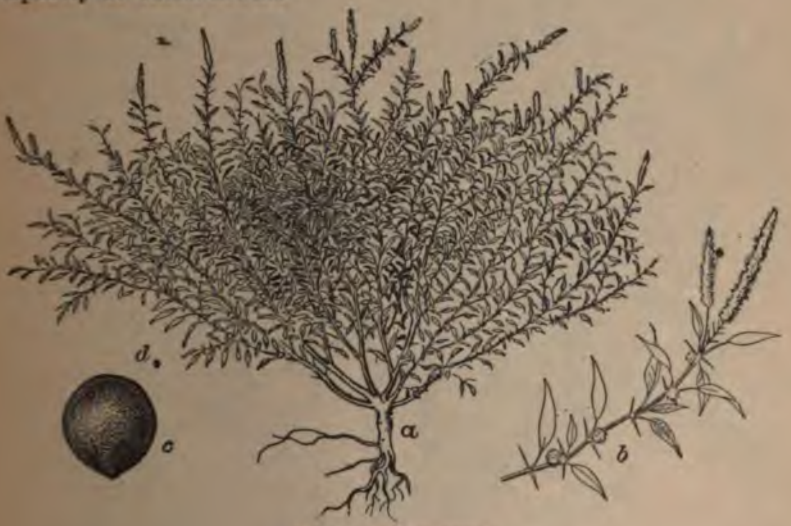

FIG. 6.—Spiny amaranth.

### SPINY AMARANTH (*Amaranthus spinosus*).

The spiny amaranth, or prickly careless weed as it is often called, is native in tropical America, and seems to have been first introduced into this country along the southeastern coast. It is now more or less abundant in most of the States south of the Potomac and Ohio rivers, and is spreading with considerable rapidity. It resembles the common tumbleweed (*Amaranthus albus*) and other amaranths or careless weeds of the neglected cornfield and garden. It is an annual with a succulent stem, branching profusely throughout and attaining a height of 15 to 30 inches (fig. 6, *a*). The leaves are dark-green, lance-ovate, smooth, about 1½ inches long. At the base of the leaf stalk in most cases are two slender sharp spines, one-fourth to one-half inch long (fig. 6, *b*).

The small, green flowers are crowded in slender spikes at the ends of the branches and in dense clusters in the axils of the leaves (fig. 6, *b*). The seeds, borne singly in the flowers, but aggregating several thousand on an average plant, are black and shining, round or slightly flattened, and about one twenty-fourth of an inch in diameter (fig. 6, *c*, *d*). They might be found in clover seed, millet, or grass seeds. The plant grows in broken ground like other amaranths, but unlike most of them, it also grows and even spreads aggressively in strong blue grass sod. No farm stock will eat it, at least after the spines begin to develop.

Like other annuals it may be subdued by preventing the production of seed. It would readily succumb to thorough cultivation, as it grows rather slowly at first and does not produce seed until midsummer or later. Mowing or grubbing up the plant before the flower spikes develop is probably the best method of eradication in permanent pastures. Potato land and corn stubble may be plowed or thoroughly disked after the crop is harvested and a winter crop sown which will keep down the weeds.

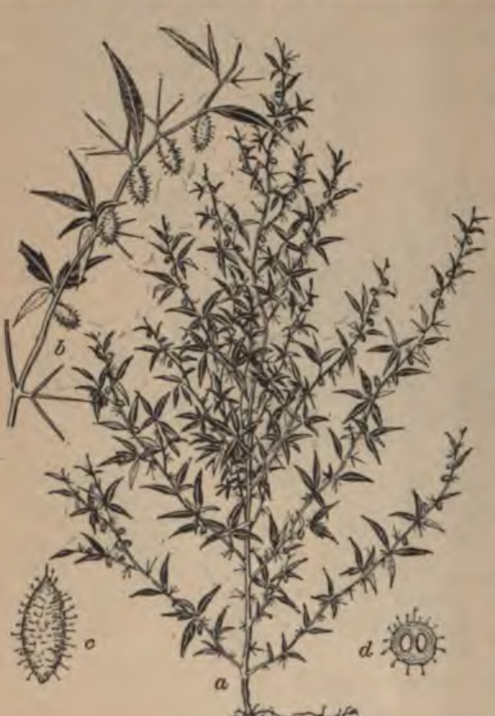

FIG. 7.—Spiny cocklebur.

### SPINY COCKLEBUR (*Xanthium spinosum*).

This plant, often called dagger cocklebur and well deserving that name as one of the most spiny of American weeds, is a native of tropical America. It has been introduced into many parts of this country, in some places doubtless having been spared, or possibly even cultivated, at first, for the striking effect produced by its shiny, dark-green foliage and its slender, bright-yellow spines. The stem branches from the base and grows to the height of 1 to 3 feet, bearing many narrowly ovate leaves about 1½ inches long, sometimes slightly toothed near the base, rather thick in texture, the upper surface dark-green with a whitish midrib and the lower white with woolly pubescence (fig. 7, *a*, *b*). At the base of the leaf stem on one side is a three-pronged spine about an inch long. On the other side is an inconspicuous flower, lowed by an oblong, spiny bur like those of the common native kleburs, but smaller, about one-half inch long (fig. 7, *b*, *c*). Each r contains two seeds.

The seeds are therefore less abundant than those of most troublesome nuals, but this apparent defect is counterbalanced by the fact that they ain their vitality many years and that the hooked spines on the burs ovide for their wide distribution by passing animals. As they remain closed in the hard, spiny bur, they are seldom found in commercial eds. Although this weed is an annual, it is most troublesome pastures and meadows, preading even in strong sod. Its growth at first is slow nd, as it needs light and oom to develop into a robust plant, it may be choked down by any quick-growing crop that will crowd and shade it. In permanent pastures and waste places, where it flourishes best, it could doubtless be eradicated in time by mowing the plants about twice each year, in August and September, or by cutting them up with a hoe or spud in May and June. As the seeds often lie dormant in the thick-walled bur (fig. 7, *d*) several years before germinating, it might require a like period to exterminate a patch by this method; but the plants would continually be growing less in number, and the labor correspondingly lighter.

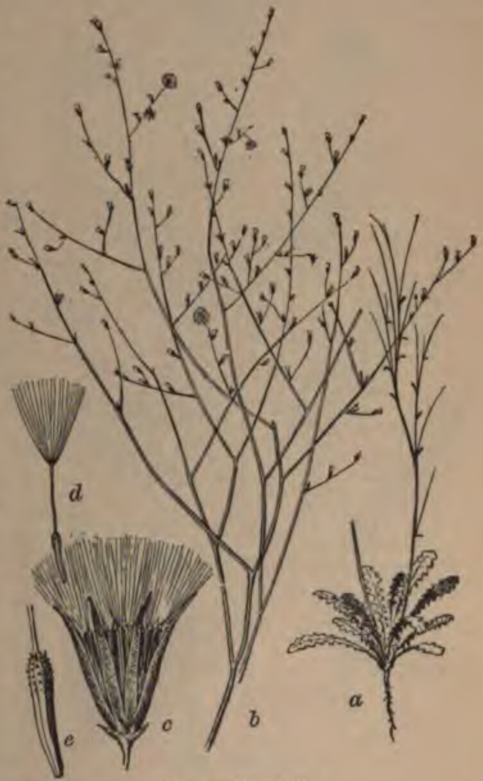

FIG. 8.—Chondrilla.

### CHONDRILLA (*Chondrilla juncea*).

This is an almost leafless, branching biennial weed, introduced from Europe and now abundant on clay knolls in the middle Atlantic coast region and in northern West Virginia. It has a rosette of root leaves similar to those of the dandelion, but the rigid, branching stems are bare except for the inconspicuous linear bracts and the small, yellow flowers (fig. 8, *a*, *b*). The lower part of the main stem is clothed with small prickles. The plant begins to bloom in June or July and continues to flower and produce seeds until killed by frost. The akenes (cases containing the seeds) are nearly black, oblong and prismatic in form, roughened at the summit with small projections (fig. 8, *e*), from among which springs a slender beak bearing a tuft of fine white hairs, or pappus, at its apex (fig 8, *d*, *e*). This pappus enables the akenes to be carried a considerable distance by the wind.

As the plant is usually most abundant in neglected pasture land where the soil is somewhat impoverished, it seems probable that cultivation and a supply of fertilizer would soon subdue it. Left unchecked it not only occupies all the space where the grass has become thin but encroaches aggressively on strong grass sod.

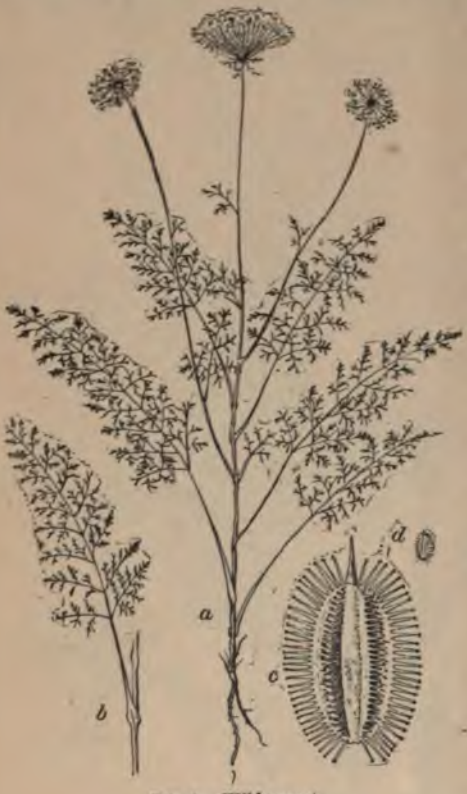

FIG. 9.—Wild carrot.

### WILD CARROT (*Daucus carota*).

The wild carrot is by no means a new weed, but it is spreading to new localities, and has consequently been the object of considerable attention during the past season. It is one of the most aggressive weeds of the Eastern States, and is rapidly spreading westward, having been found at several points west of the Mississippi River. It seems to thrive well in nearly all kinds of soils, and in all climates from Maine to Georgia. As capable of becoming troublesome over a wide area, therefore, the wild carrot is probably one of the worst weeds that we have.

Its flat cymes of white flowers, usually with a small purple flower in the center of each cyme, appear from June until September, and they are followed by contracted, cup-shape clusters of small bur-like, one-seeded fruits, usually called seeds (fig. 9, *c*, *d*). These seed-fruits are readily attached to passing animals and are distributed in that way, or they often remain undisturbed on the plant until winter and are then blown across the snow. Too often they are found in poorly cleaned clover and grass seed. The seeds inclosed in their hard, spiny coat retain their vitality for several years, and when once abundant in the soil they are likely to cause trouble during several seasons, even though fresh seeding is prevented.

In permanent pasture the persistent mowing of the plants as often as the flower appears will eventually destroy them. They will continue to separate florets falling as soon as ripe, and by the long, stout, twisted and bent awns borne by the first and second florets (fig. 10, *c*, *d*). The floral glume, inclosing the grain, is hairy below the middle, usually nearly black at maturity (fig. 10, *d*), and is harder and tougher than that of the cultivated oat, while the grain is very light in weight, much lighter than in any of the cultivated varieties of white oats.

The grain retains its vitality much longer than does the common oat, and may remain buried in the soil several years without germinating. It germinates best when there is an abundance of moisture and the soil is warm. To clear the seed out of the soil, therefore, the land should be stirred when it is warm and as moist as will permit good cultivation. It is understood, of course, that cultivating the land when wet, especially in clay soils, is bad policy, and it is advocated in this case only for a special purpose. The clearing of the soil can be accomplished in conjunction with the cultivation of corn or root crops. If summer-fallowing is practiced, the land should be rolled after cultivation, when not too wet, to conserve moisture and pack it closely about the seeds near the surface. Where winter wheat and rye may be grown profitably the land should be plowed as soon as possible after the spring crop is harvested, and harrowed about once a week until time for sowing the wheat or rye. Oats should be left out of the rotation so far as may be until the wild oats are subdued, as the latter growing among the cultivated oats are difficult to detect for removal, and after harvesting and thrashing it is practically impossible to separate completely the two kinds of grain. In other grain crops the wild oat may be pulled or cut and removed by hand before maturity in the same manner as wild mustard or rye. Where it is very abundant, however, this plan would be too laborious to pursue with profit, and the crop would better be mown for hay or plowed under. No oats should be sown coming from farms where the wild oat is known to grow.

### FALSE FLAX (*Camelina sativa*).

This plant, a member of the mustard family, has been introduced from Europe, where it has long been known as a troublesome weed in flax fields. It resembles flax somewhat, but has much smaller flowers and seeds, and its seed capsules are pear-shaped instead of spherical (fig. 11, *a*). It is an annual, like shepherd's purse, peppergrass, and most of the other troublesome weeds of the mustard family. In the northern part of its range, at least, the seeds are seldom matured except on plants which grow as winter annuals. The seeds germinating in the fall produce a rosette of leaves in the same manner as the dandelion. In the spring a seed stalk is developed from the midst, and after the seeds are matured the plant dies. The seeds germinating in the spring produce plants that usually blossom during the same season, but seldom mature seeds, being killed too early by the frost.

# TABLE OF ONE HUNDRED WEEDS.

NOTE 1.—This table presents the common and technical name, with some of the characteristics, of one hundred weeds which are regarded as the most troublesome in the United States.

NOTE 2.—By alternate cultivation and smothering crops is meant clean cultivation during the dry season and a heavy seeding of some annual crop, as crimson clover, cowpeas, millet, or oats, that will cover the ground thickly and choke down the weeds during the growing season.

NOTE 3.—Under color and size of flowers the most prominent color and the approximate diameter of a single flower, or of a head in the case of composites, are given.

| Common names. | Technical name. | Where injurious. | Duration. | Time of flowering. | Time of seeding. | Color, size, and arrangement of flowers. | Methods of propagation and distribution of seed. | Place of growth and products injured. | Methods of eradication. |
|---|---|---|---|---|---|---|---|---|---|
| Barn grass, barnyard grass, cockspur. | Panicum crus-galli | Minnesota to Montana. | Annual ... | June to August. | July to September. | Green; [illegible] inch; panicle. | Seeds; in grain seed. | Fields; spring wheat. | Prevention of seeding. |
| Black mustard ........... | Brassica nigra .... | Washington to California. | .....do .... | June to September. | July to October. | Yellow; [illegible] inch; panicle. | Seeds; in grass and grain seed. | Fields; grain crops. | Prevention of seeding; hoed crops. |
| Bracted plantain, rib grass, buckhorn. | Plantago aristata . | Ohio to Iowa . | .....do (?). | May to October. | June to December. | Green; [illegible] inch; spike. | Seeds; in grass and clover seed. | Meadows, pastures. | Do. |
| Brake, eagle fern......... | Pteris aquilina.... | Washington to California. | Perennial | ............ | ............ | Flowerless .. | Rootstocks; spores. | ... do ....... | Heavy seeding; cultivation. |
| Broom rape ...... ...... | Orobanche ramosa | Kentucky to North Carolina. | Annual .. | June to August. | July to September. | White; [illegible] inch; spike. | Seeds ........ | Hemp; tobacco | Clean seed. |
| Buffalo bur, beaked horse nettle. | Solanum rostratum | Iowa to Colorado. | .... do .... | June to September. | July to November. | Yellow; [illegible] inch | Seeds; tumble weed. | Grain; hoed crops. | Heavy seeding; close cultivation. |
| Bull thistle, common thistle. | Carduus lanceolatus. | Everywhere ... | Biennial .. | June to August. | .....do ..... | Purple; 1 inch; head. | Seeds; wind.... | Meadows; winter wheat. | Prevention of seeding; cutting in fall. |
| Burdock, great dock ..... | Arctium lappa.... | New England to Wisconsin. | .... do .... | July to September. | August to October. | Purple; [illegible] inch; head. | Seeds; animals. | Waste places; pastures; wool. | Prevention of seeding; grubbing in summer. |
| Bur grass, hedgehog grass, Rocky Mountain sand bur, sand bur, sand spur. | Cenchrus tribuloides. | Everywhere ... | Annual ... | June to October. | July to November. | Green; bur.... | .....do ......... | Sandy pastures; wool. | Cultivation; burning. |
| Buttonweed............. | Diodia teres....... | Maryland to Alabama. | .....do .... | .....do ..... | .....do ..... | Green; 1 line; axillary. | Seeds .......... | Waste places, hoed crops; grainfields. | Prevention of seeding; close cultivation. |
| Canada thistle ........... | Carduus arvensis . | New England to Michigan. | Perennial . | June to September. | July to October. | Purple; [illegible] inch; head. | Rootstocks; seeds. | Fields; grain; meadows. | Alternate cultivation and heavy cropping. |
| Charlock, wild mustard.. | Brassica arvensis. | New England to New Jersey. | Annual ... | May to September. | June to October. | Yellow; [illegible] inch; panicle. | Seeds; in grain seed. | Fields; grain.. | Prevention of seeding; cultivation; hoed crops. |
| Chess, cheat, wheat thief, Willard's brome grass. | Bromus secalinus. | New England, to Washington. | .....do .... | July to September. | August to October. | Green; panicle | .....do ......... | .....do ........ | Clean seed. |

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|---|---|---|---|---|---|---|---|---|---|
| skeleton weed, stick-weed. | Chondrilla juncea. | West Virginia to Maryland. | Biennial .. | June to November. | July to December. | solitary. | | pastures. | crops. |
| Clover dodder, devil's gut, dodder. | Cuscuta trifolii... | New York to North Carolina and westward. | Annual ... | .....do ..... | June to November. | Yellow; ⅛ inch; clusters. | Seeds; in clover and alfalfa seed. | Clover; alfalfa. | Clean seed. |
| Cockle, corn cockle, rose campion. | Agrostemma githago. | New England to Washington. | .....do .... | June to August. | July to September. | Purple; 1 inch; solitary. | Seeds; in grain seed. | Grainfields; wheat. | Do. |
| Cocklebur, clot bur, ditch bur, small burdock. | Xanthium canadense, Xanthium strumarium. | Everywhere ... | .....do .... | July to October. | August to November. | Green; ⅛ inch; heads. | Seeds; animals. | Waste places; pastures; wool. | Prevention of seeding; cultivation. |
| Couch grass, quack grass, quick grass, witch grass, devil's grass, durfee grass | Agropyron repens. | New England to Minnesota. | Perennial . | July to August. | August to September. | Green; spikes. | Rootstocks..... | Fields; all crops except hay. | Alternate cultivation and heavy cropping. |
| Cow herb, cockle, cow basil, cow fat, glond. | Saponaria vaccaria. | Colorado to Utah. | Annual ... | June to July. | July to August. | Pink; ¾ inch; cymes. | Seeds; in grain seed. | Fields; grain.. | Prevention of seeding; clean seed. |
| Crab grass, finger grass, Polish millet. | Panicum sanguinale. | New Jersey to Missouri and south. | Perennial . | June to September. | July to October. | Green; spikes. | Seeds .......... | Hoed crops.... | Prevention of seeding; closer cultivation. |
| Curled dock, yellow dock. | Rumex crispus.... | New England to Washington. | .....do .... | .....do ..... | .....do ..... | Green; ½ inch; panicle. | .....do ......... | Meadows; grain crops. | Alternate cultivation and heavy cropping. |
| Dandelion ................ | Taraxacum taraxacum. | Nearly everywhere. | Biennial .. | May to October. | May to November. | Yellow; 1 inch; head. | Seeds; wind.... | Meadows; lawns. | Cultivation. |
| Devil's weed, devil's paint brush, king devil weed, golden hawkweed | Hieracium præaltum. | New York..... | Perennial . | July to September. | August to October. | .....do ........ | Seeds; wind; rootstocks. | Meadows; pastures. | Sheep pasturing; cultivation and heavy cropping. |
| Dog fennel, Mayweed.... | Anthemis cotula.. | Everywhere ... | Annual ... | June to August. | July to September. | White; ¾ inch; head. | Seeds .......... | Roadsides..... | Prevention of seeding. |
| English bindweed, morning-glory. | Convolvulus arvensis. | New England and California. | Perennial . | June to September. | August to October. | White; 1 inch; solitary. | Seeds; rootstocks. | Grainfields; hoed crops. | Prevention of seeding; late cultivation. |
| False flax, gold of pleasure; wild flax. | Camelina sativa... | Michigan to Minnesota. | Annual ... | May to July | June to August. | Yellow; ⅛ inch; raceme. | Seeds; in flax and grain seed. | Flax and winter grain. | Prevention of seeding. |
| Fleabane, daisy fleabane, sweet scabious, white-top. | Erigeron annuus.. | Maine to Minnesota and south | .....do .... | June to August. | July to September. | White; ⅜ inch; heads. | Seeds .......... | Waste places; meadows. | Do. |
| Franseria ............... | Gærtneria discolor | Wyoming to New Mexico. | Perennial . | .....do ..... | .....do ..... | Yellow; ¼ inch; heads. | Rootstocks..... | .....do ........ | Thorough cultivation. |
| Great ragweed, hogweed. | Ambrosia trifida.. | Iowa to Louisiana and east. | Annual ... | July to September. | August to October. | .....do ........ | Seeds .......... | Bottom lands.. | Cultivation; heavy cropping. |
| Gum plant, rosinweed, sunflower. | Grindelia squarrosa. | North Dakota to Utah. | .....do .... | .....do ..... | August to November. | Yellow; ⅝ inch; heads. | Seeds; animals. | Meadows; pastures. | Prevention of seeding; cultivation. |
| Hedge bindweed, morning-glory. | Convolvulus sepium. | New Jersey to Illinois. | Perennial . | .....do ..... | August to October. | White; 2 inches; solitary. | Seeds .......... | Corn and grainfields. | Late cultivation. |

*Table of one hundred weeds*—Continued.

| Common names | Technical name | Where injurious. | Duration. | Time of flowering. | Time of seeding. | Color, size, and arrangement of flowers | Methods of propagation and distribution of seed. | Place of growth and products injured. | Methods of eradication. |
|---|---|---|---|---|---|---|---|---|---|
| Hogweed | Boerhaavia erecta | Louisiana to Texas | Annual | June to November. | July to December. | White, 1/8 inch; cyme. | Seeds | Meadows, cultivated land. | Prevention of seeding; thorough cultivation. |
| Horse nettle, bull nettle, sand briar. | Solanum carolinense. | Iowa to New Jersey and south. | Perennial | June to October. | August to November. | Purple, 1 inch, solitary. | Seeds, rootstocks. | Waste land; meadows, pastures. | Alternate cultivation and heavy cropping. |
| Horseweed, butterweed, colt's tail, fleabane. | Erigeron canadensis | Everywhere | Annual | June to September. | July to October. | White, 1/8 inch, head. | Seeds, wind | Waste land, meadows, grainfields. | Prevention of seeding, late cultivation. |
| Indian mallow, butter print, stampweed, velvet leaf. | Abutilon avicennae. | Illinois to Iowa and Missouri | do | July to August | August to September. | Yellow, 1/2 inch, solitary. | Seeds | Cultivated lands. | Prevention of seeding. |
| Jimson weed, Jamestown weed, thorn apple. | Datura tatula | Virginia to Texas. | do | July to September. | August to October. | Purple; 3 inches, solitary. | do | Waste places | Do. |
| Johnson grass, Cuba grass, Australian millet, Egyptian millet, evergreen millet, Means's grass | Andropogon halepensis | North Carolina to Texas and California. | Perennial | June to August. | July to September. | Green; 1/4 inch, panicle. | Rootstocks; seeds. | Cultivated fields; hoed crops. | Alternate cultivation and heavy cropping. |
| Lamb's quarters, pigweed | Chenopodium album | Everywhere | Annual | July to September. | August to November. | Green; 1/16 inch; panicle. | Seeds | Waste places | Prevention of seeding. |
| Live forever, garden orpine. | Sedum telephium | New York to Pennsylvania | Perennial | July to August. | August to September. | Purple; 1/4 inch; cyme. | Rootstocks; seeds. | Fields | Infection with fungous disease; close cultivation. |
| Malva | Malva parviflora. | California | do | June to August. | July to September. | Purple; 1/4 inch, solitary. | Seeds; rootstocks. | do | Prevention of seeding; thorough cultivation. |
| Manroot, man of the earth, morning-glory. | Ipomoea pandurata. | Delaware to Missouri. | do | July to September. | August to October. | White; 3 inches; solitary. | do | do | Prevention of seeding; killing roots with coal oil. |
| Marsh elder, high water shrub. | Iva xanthiifolia. | Minnesota to Utah. | Annual | August to September. | September to October. | Green; 1/8 inch; heads. | Seeds | Fields; pastures; grain crops. | Prevention of seeding. |
| Mexican tea, pigweed | Chenopodium ambrosioides. | Virginia to Louisiana. | do | do | August to October. | Green; 1/16 inch; spikes. | do | Waste places | Do. |
| Milkweed, cottonweed, | Asclepias syriaca | New York to Nebraska | Perennial | July to August. | August to September. | Purple; 1/2 inch; umbel. | Seeds; wind; rootstocks. | Fields | Prevention of seeding; cultivation, heavy cropping. |
|  |  |  |  |  |  |  |  | [illegible] | Prevention of seed- |

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|---|---|---|---|---|---|---|---|---|---|
| needle, musky heron-bill. | tum. | Arizona. | | July. | gust. | umbel. | | | burning. |
| Narrow-leafed stickseed, beggar tick. | Lappula lappula.. | Everywhere ... | .....do .... | July to September. | July to October. | Blue; ⅛ inch; raceme. | Seeds; animals. | Everywhere; all crops. | Sowing clean seed; cultivation. |
| Nut sedge, nut grass, coco, coco sedge. | Cyperus rotundus. | Maryland to Arkansas and Texas. | Perennial . | July to October. | August to November. | Brown; $\frac{1}{16}$ inch; spikelets. | Tubers; in nursery packing; seeds. | In hoed crops . | Alternate cultivation and smothering crops. |
| Orange hawkweed, ladies' paint brush, red daisy. | Hieracium aurantiacum. | New York..... | .....do .... | July to September. | August to October. | Orange; ⅛ inch; solitary. | Seeds; wind; rootstocks. | Meadows; pastures. | Prevention of seeding; cultivation. |
| Ox-eye daisy, bull's-eye, white daisy, whiteweed. | Chrysanthemum leucanthemum. | Maine to Virginia and Ohio. | .....do .... | June to September. | July to October. | White; 1 inch; solitary. | Seeds; rootstocks. | .....do ........ | Do. |
| Paraguay bur, sheep bur. | Acanthospermum xanthioides. | North Carolina to Florida. | .....do .... | May to November. | June to December. | Yellow; ¼ inch; heads. | Seeds; animals; rootstocks. | Waste places; pastures; wool. | Cultivation. |
| Paroquet bur ............ | Sida stipulata..... | Alabama to Florida. | ............ | June to November. | July to December. | Yellow; 1 inch; solitary. | Seeds; animals. | Waste places; cultivated land; wool. | Do. |
| Passion flower, maypop .. | Passiflora incarnata. | North Carolina to Florida. | Perennial . | July to September. | August to October. | White; 2 inches; solitary. | Seeds .......... | Hoed crops.... | More thorough cultivation; prevention of seeding. |
| Pennycress, Frenchweed. | Thlaspi arvense... | North Dakota to Minnesota. | Annual ... | May to November. | June to December. | White; ⅛ inch; raceme. | Seeds; wind.... | Grainfields; pastures; dairy products. | Burning; thorough cultivation. |
| Pigeon grass, foxtail, yellow foxtail. | Setaria glauca..... | Everywhere ... | Annual ... | June to September. | July to November. | Green; $\frac{1}{16}$ inch; spikes. | Seeds; in clover seed. | Cultivated land; grain crops. | Do. |
| Pigweed, careless weed, rough amaranth. | Amarantus retroflexus. | .....do ......... | .....do .... | July to October. | August to November. | Green; $\frac{1}{16}$ inch, spikes. | Seeds .......... | Cultivated land; all crops. | Prevention of seeding; thorough cultivation. |
| Poison ivy, poison oak, poison vine. | Rhus radicans .... | .....do ......... | Perennial . | June to July. | July to August. | Yellow; ¼ inch; raceme. | Rootstocks; seeds. | Waste land; poisonous to man. | Cultivation; repeated grubbing. |
| Poverty weed ............ | Iva axillaris....... | Montana to New Mexico. | .....do .... | June to August. | July to September. | Yellow; ¼ inch; heads. | Rootstocks; seeds. | Cultivated land; all crops. | Closer cultivation; smothering crops. |
| Prickly lettuce, compass plant, milkweed, wild lettuce. | Lactuca scariola.. | Ohio to Iowa and Utah to Oregon. | Annual ... | June to October. | July to November. | .....do ........ | seeds; wind.... | Everywhere; all crops. | Prevention of seeding; burning. |
| Purslane, garden purslane, pursley, pusley. | Portulaca oleracea. | Everywhere ... | .....do .... | May to November. | June to December. | Yellow; ¼ inch; solitary. | Seeds.......... | Cultivated land; garden crops. | Closer cultivation. |
| Ragweed, bitterweed, hogweed, richweed, Roman wormwood. | Ambrosia artemisiæfolia. | .....do ......... | .....do .... | July to October. | August to November. | ....do ........ | Seeds; wind.... | Everywhere; all crops. | Prevention of seeding; burning. |
| Rattlebox ................ | Crotalaria sagittalis. | Iowa to South Dakota. | .....do .... | July to September. | .....do ..... | .....do ........ | Seeds .......... | Pastures; poisonous to stock. | Cultivation. |

| uri- | Duration. | Time of flowering. | Time of seeding. | Color, size, and arrangement of flowers. | Methods of propagation and distribution of seed. | Place of growth and products injured. | Methods of eradication. |
|---|---|---|---|---|---|---|---|
| ery- | Perennial . | June to October. | July to November. | White; $\frac{1}{16}$ inch; spike. | Seeds; rootstocks. | Everywhere; all crops. | Clean seed; cultivation. |
| d to<br>Caro- | .....do .... | May to July. | June to August. | White; 1 inch; solitary. | Seeds; birds; rootstocks. | Fields; all crops. | Cultivation; smothering crops. |
| to<br>. | Annual ... | July to September. | August to November. | Purplish; $\frac{1}{4}$ inch; solitary. | Seeds; wind.... | Everywhere; small grain. | Cultivation; burning. |
| re ... | .....do .... | March to December. | May to December. | White; $\frac{1}{16}$ inch; raceme. | Seeds .......... | Everywhere; all crops. | Cultivation. |
| Ari- | .....do .... | June to July. | July to August. | White; $\frac{1}{8}$ inch; umbel. | Seeds; animals; wind. | .....do ........ | Prevention of seeding; cultivation. |
| Ne- | .....do .... | July to August. | August to September. | Pink; $\frac{1}{16}$ inch; spike. | Seeds .......... | .....do ........ | Do. |
| olina<br>. | Perennial . | July to September. | August to October. | Yellow; $\frac{1}{2}$ inch; head. | Seeds; rootstocks. | Meadows; pastures. | Cultivation. |
| ery- | .....do .... | May to October. | June to November. | Red; $\frac{1}{2}$ inch; panicle. | Seed, in clover seed; rootstocks. | .....do ........ | Cultivation; smothering crops. |
| olina<br>ia. | .....do .... | .....do ..... | .....do ..... | Reddish; $\frac{1}{8}$ inch; panicle. | Seeds; rootstocks. | .....do ........ | Thorough cultivation. |
| land<br>nsin. | .....do .... | July to October. | August to November. | Yellow; $\frac{3}{4}$ inch; heads. | Seeds; wind; rootstocks. | Meadows; pastures; grainfields. | Thorough cultivation and smothering crops. |
| re ... | Annual.... | June to September. | July to November. | .....do ........ | Seeds; animals. | Waste land; pastures. | Prevention of seeding. |
| to | .....do .... | July to November. | August to December. | Green; $\frac{1}{16}$ inch; spikes. | Seeds .......... | .....do ........ | Do. |
| olina<br>sippi. | .....do .... | June to September. | July to October. | White; 1 inch; raceme. | .....do ........ | Waste places; pastures. | Prevention of seeding; cultivation. |
| l to<br>and<br>a. | .....do .... | July to October. | August to November. | Green; $\frac{1}{8}$ inch; head. | Seeds; animals. | Waste land; pastures; wool. | Do. |
| tah.. | .....do .... | June to September. | July to October. | Green; spike .. | Seeds; wind; animals. | Pastures ...... | Do. |

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| | | | | | | | | | ble. |
| Sunflower, common sunflower. | Helianthus annuus. | Nebraska to Louisiana. | .....do .... | July to September. | August to October. | Yellow; 1½ inch; heads. | .....do ......... | .....do ......... | Prevention of seeding. |
| Tarweed ................ | Madia sativa...... | Washington to California. | .....do .... | May to October. | June to November. | Yellow; ¾ inch; heads. | Seeds; animals. | Roadsides; cultivated land. | Prevention of seeding; burning. |
| Toadflax, butter-and-eggs, devil's flax, impudent lawyer, ramstead, snapdragon. | Linaria vulgaris .. | New England to Wisconsin. | Perennial. | July to October. | August to November. | Yellow; ½ inch; raceme. | Rootstocks; seeds. | Meadows; pastures. | Cultivation; heavy cropping. |
| Teasle, English thistle, fuller's card. Hutton-weed, Indian thistle. | Dipsacus sylvestris. | Ohio to Tennessee. | Biennial .. | July to September. | August to October. | White; 1 inch; head. | Seeds ......... | .....do ......... | Prevention of seeding; cultivation. |
| Tumbleweed, pigweed.... | Amaranthus albus | Minnesota to Kansas. | Annual ... | August to September. | .....do ..... | Green; $\frac{1}{16}$ inch; spike. | Seeds; wind ... | Cultivated land. | Prevention of seeding; burning. |
| Vipers bugloss, blue thistle, blueweed. | Echium vulgare... | New York to North Carolina. | Biennial .. | June to October. | July to November. | Blue; ½ inch; thyrsus. | Seeds .......... | Meadows; pastures. | Alternate cultivation and heavy cropping. |
| Wheat thief, corn gromwell, field gromwell, pigeonweed, redroot, stone seed. | Lithospermum arvense. | Michigan to Ohio. | Annual ... | June to September. | July to October. | White; ¼ inch; solitary. | Seeds, in grain seed. | Grainfields.... | Sowing clean seed; cultivation with hoed crops. |
| Wild buckwheat, black bindweed. | Polygonum convolvulus. | Michigan to North Dakota. | .....do .... | .....do ..... | .....do ..... | White; ¼ inch; raceme. | .....do ......... | Grain and corn fields. | Sowing clean seed; cultivation. |
| Wild carrot, bird's nest, devil's plague, Queen Anne's lace. | Daucus carota .... | New England to Virginia. | Biennial .. | June to October. | July to November. | White; ⅛ inch; umbel. | Seeds; animals; wind. | Meadows; pastures. | Grubbing in fall; cultivation. |
| Wild gourd .............. | Cucurbita perennis. | California to New Mexico. | Perennial. | April to July. | June to September. | Yellow; 3 inches; solitary. | Seeds .......... | Cultivated land. | Killing the roots with coal oil. |
| Wild mustard, charlock, yellow mustard. | Brassica sinapistrum. | New England to Oregon. | Annual ... | June to September. | July to October. | Yellow; ½ inch; raceme. | .....do ......... | Grainfields.... | Prevention of seeding; cultivation in hoed crops. |
| Wild oats ................ | Avena fatua ...... | Minnesota to Oregon. | .....do .... | July to August. | July to September. | Green; ¾ inch; panicle. | Seeds, in seed oats. | Oatfields ...... | Sowing clean seed; burning; pasturing. |
| Wild onion, field garlic, wild garlic. | Allium vineale.... | Pennsylvania to South Carolina. | Perennial. | .....do ..... | August to September. | White; ⅛ inch; umbel. | Bulblets; seeds. | Everywhere; dairy products; grain. | Alternate cultivation and heavy cropping. |
| Wild parsnip, queenweed. | Pastinaca sativa .. | New England to Wisconsin. | Biennial .. | June to September. | July to October. | Yellow; ⅛ inch; umbel. | Seeds .......... | Meadows; pastures. | Prevention of seeding; cultivation. |
| Wild senna, teaweed ...... | Cassia marylandica. | Maryland to Texas. | .... do .... | June to July | July to August. | Yellow; ¾ inch; raceme. | Seeds; rootstocks. | Cultivated land. | Cultivation and smothering crops. |
| Wild tobacco............. | Nicotiana attenuata. | California to Arizona. | Annual ... | May to July | June to August. | White; ¼ inch; raceme. | Seeds .......... | Cultivated and waste land. | Prevention of seeding. |

*Table of one hundred weeds*—Continued.

| Common names. | Technical name. | Where injurious. | Duration. | Time of flowering. | Time of seeding. | Color, size, and arrangement of flowers. | Methods of propagation and distribution of seed. | Place of growth and products injured. | Methods of eradication. |
|---|---|---|---|---|---|---|---|---|---|
| Yellow daisy, brown-eyed Susan, cone flower, niggerhead, ox-eye daisy. | Rudbeckia hirta... | New England to Ohio. | Biennial .. | June to August. | July to September. | Yellow; 1 inch; head. | Seeds .......... | Meadows; pastures. | Prevention of seeding; cultivation. |
| Yellow dock, bitter dock, broad-leafed dock. | Rumex obtusifolius. | New England to Wisconsin. | Perennial . | July to September. | August to October. | Green; ⅛ inch; raceme. | .....do ......... | Meadows; pastures. | Do. |
| Yellow dog fennel........ | Helenium tenuifolium. | Nebraska to Mississippi. | Annual ... | July to October. | August to November. | Yellow; ¼ inch; head. | .....do ......... | Waste land; pastures. | Do. |
| Yerba mansa............. | Anemopsis californica. | California to Arizona. | Perennial . | May to September. | June to October. | White; ¼ inch; spike. | Rootstocks; seeds. | Moist land; cultivated crops. | Alternate cultivation and heavy crops. |

## FARMERS' BULLETINS.

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Farmers' Bulletin No. 9. Milk Fermentations and their Relations to Dairying.
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Farmers' Bulletin No. 23. Foods: Nutritive Value and Cost. Pp. 32. Issued
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FARMERS' BULLETIN No. 29.

# OURING OF MILK

AND

# OTHER CHANGES IN MILK PRODUCTS.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.

[Issued August, 1895.]

WASHINGTON:
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1895.

# LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
*Washington, D. C., June 15, 1895.*

SIR: I have the honor to transmit herewith for publication a Farmers' Bulletin an article on the fermentations of milk and its pr ucts and the means of preventing or controlling them. This bull is a revision of Farmers' Bulletin No. 9, on Milk Fermentations a their Relations to Dairying, which was originally prepared from review by Prof. W. H. Conn of the investigations on the fermentati of milk. Considerable new matter has been added, especially on t practical bearing of these fermentations on the care and handling milk and on butter and cheese making. The revision and additi have been made on the basis of a later article by Professor Co bringing the subject down to the present time. These matters a assuming more and more importance every year as they are bet understood. As rapid progress is being made in dairy bacteriolog especially in its application, it is important that farmers and dairym

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# SOURING OF MILK AND OTHER CHANGES IN MILK PRODUCTS.

## INTRODUCTION.

The souring of milk is due to the action of minute organisms known as bacteria. These bacteria are so minute that they can be seen only by the aid of a powerful microscope, but the result of the concerted action of myriads of them in souring milk is a familiar sight to every housewife. Besides the ordinary souring of milk, there are many other changes which may take place—as the ripening of cream, the ripening of cheese, butter becoming rancid, and many others less common. These changes are called fermentations, because they are similar to the fermenting of cider to vinegar, the fermentations produced by yeast in beer making, etc. The term includes many changes due to other micro-organisms or ferments besides bacteria; and so here fermentation is used to cover all the changes which occur in milk, such as curdling, souring, and putrefaction, most of which are caused by bacteria. The great importance of these fermentations of milk is being realized. It is only by a proper control of them that good butter or cheese can be made. It is important that they should take place, but it is equally important that they should not be allowed to get the upper hand. To insure an understanding of these fermentations of milk some knowledge of the chemical composition of milk is necessary.

## COMPOSITION OF MILK.

While the composition of milk obtained from different cows and produced under different conditions shows wide variations, a fair average composition may be given as follows: Water, 87 per cent; solids, 13 per cent. The solids include fat, 3.6; casein, 3.3; albumen, 0.7; milk sugar, 4.7; and ash, 0.7 per cent. The casein and albumen are the materials containing nitrogen, and are of special importance in cheese making. In general, the ash, sugar, and albumen are in solution, the casein in partial solution, and the fat in suspension, but not dissolved in the milk.

*Milk fat* consists of a mixture of several fats. As its composition begins to undergo changes almost immediately after the milk is drawn, its exact condition at any moment is very uncertain. It is distributed throughout the milk in the form of minute globules, varying in size.

obtaining milk from the cow without bacterial contamination are extremely great and sometimes seemingly insurmountable. Of the many attempts which have been made to obtain milk in this way which shall from the first be sterile, most have proved failures. Enough of them have met with success to demonstrate the general position; but so many of them have been unsuccessful as to show the xtreme difficulty of obtaining sterile milk in this way. In spite of leanly methods, of sterilized vessels, and of the greatest care to revent dirt and dust from falling into the milk, the milk when first rawn from the cow has in the large majority of cases contained bac- eria. The explanation of this fact has proved to be in the ease with hich the milk is contaminated in the milk duct. The milk duct is, course, open to the air, and it will contain at the close of the ilking a considerable amount of milk adherent to its walls. Bac- ria from the air have no difficulty in making their way into the duct, owing there, and becoming extremely numerous. The result is that the time of the next milking the milk ducts contain bacteria in eat numbers, and these will inevitably contaminate the milk. It s been suggested that the bacteria not only enter into the milk cts between the milking, but that some of them actually make their y into the very depths of the milk gland itself, and there grow and ltiply. Undoubtedly the milk gland of the healthy cow produces lk which is uncontaminated with bacteria, but the large caliber of e milk duct makes it possible for the bacteria to grow in the duct to nsiderable extent, so that it becomes a matter of extreme difficulty obtain milk from the cow, even with the greatest precautions, which all not be contaminated.

Of late the air has come to be regarded as a less important source contamination than formerly. It is of course true that milk does eive some bacteria from the air during the milking. In an ill-ven- ated stall, filled with dust from hay, bacteria will be floating in the . When the milking occurs quantities of dirt and dust are brushed m the undersides of the cow's body and fill the air in the immediate inity with bacteria; but such contamination is to be charged to the y or dirt on the cow rather than the air.

The milk vessels themselves are an important source of contamina- on, as are also the hands and clothing of the milker. The milker seldom akes a cleanly toilet before milking, and any dirt upon his hands or pon his clothing will have abundant chance to get into the milk ves- ls. The ordinary water in which the milk vessels are washed, and specially with which the milk is too frequently diluted, is also regarded s a very important source of bacteria contamination, particularly in onnection with certain disease germs, like those of typhoid fever. t a more careful consideration of the work of the last few years ws that the great sources of bacteria contamination are from the itself, not, as we have seen, from internal, but from external sources.

Anyone who has noticed the uncleanly condition in which the
kept on the ordinary farm will readily appreciate this possibilit

The other sources of dirt are very great. The hairs of t
are always covered with dirt and dust, and it is impossible
milker to avoid a considerable amount of this dirt falling into h
pail. Every one of these hairs which finds its way into the mi
furnish large quantities of bacteria for contamination. Milk
into a sterilized vessel was found to contain 520 bacteria per cub
timeter, but when drawn into a flaring pail, with considerable di
ance of the udder and bedding, the number rose to 30,000 per
centimeter. When we examine the amount of solid material
finds its way into the milk we are amazed at the results. If or
milk is allowed to stand for a number of hours a sediment may
lected which is wholly extraneous matter, and must be regar
dirt contamination. This dirt is largely composed of manur
most of the rest can be traced directly to the cow.

We must, then, regard external conditions connected with th
as the great and the most important source of bacteria that co
nate milk. We must also recognize that occasionally diseased
are a source of milk contamination. In such cases there is pr
active bacteria multiplication in the interior of the gland, and
quently abundant internal sources of milk contamination.

There is now also abundant evidence for the conclusion that th
of tuberculous cattle, at least in certain stages of the disease,
contaminated with the tuberculosis germ. This appears to be
all events after the disease has attacked the milk glands, and p
before. The great prevalence of tuberculosis among cattle mak
source of milk contamination one of considerable importance.
is also evidence that diphtheria may affect the cow, and that
under some conditions the cow thus affected may serve as a so
diphtheria contamination to the milk.

It will be seen in general, then, that in dealing with health
the greatest source of contamination is the bacteria in the milk d
the dirt on the hairs of the cow. The next greatest source is th
vessels and the milker himself. Lastly, and to a very slight ext
must look upon air as a source of contamination, but if care b
of the food and dirt on the cow little need be feared from the ai

There are other sources of milk contamination after the m
Probably some of them are of considerable importance, althoug
of them for practical purposes have so much importance as
mentioned.

## NUMBER OF BACTERIA IN MILK.

The work of the last few years has emphasized the fact that th
ber of bacteria present in milk is of very little significance. The
possible variations in these numbers seem to be found under

tical conditions. While it is true that the general purity of the
can be estimated by the number of bacteria that it contains, this
nly true to a limited extent, and not infrequently the presence of
e numbers of bacteria is possible even in very good quality of milk.
no time in the history of the milk can anything like uniformity in
numbers be given. Immediately after milking the number may
from zero to over 10,000,000 in a single cubic inch of milk. The
ber depends upon various conditions of cleanliness. After the
is drawn the bacteria begin to multiply rapidly, and the number
ent at any moment subsequently will depend simply upon the tem-
ture at which the milk is kept and upon the species of bacteria
ent. Some species seem to multiply rapidly and to reach higher
bers than others. The favorable influence of warmth on the growth
acteria makes more evident the value of keeping milk as cool as
ible from the very outset, if we wish to avoid the troublesome
wth of bacteria. For a day or two the bacteria increase with great
dity, then their multiplication is checked, and finally they entirely
se to grow. This can not, of course, be due to a lack of food, for
re is plenty of food in the milk at all times. It is rather to be
ributed to the accumulation of the products of their action. Those
wths which produce an acid will soon be checked by this, for bacteria
not grow in an acid medium. The amount of acid formed before
growth is checked will vary, however, for some species of bacteria
very sensitive to acid, while others will endure a larger amount
hout injury.

n regard to the milk supply of cities and towns, the number of bac-
a varies very greatly. An important factor is the time between
king and delivery to customers. In large cities this often amounts
wenty-four or thirty-six hours. When this is the case it is neces-
to keep the milk on ice, and by doing so the milk is kept fairly
h. Judging from tests thus far made, city milk which contains not
e than three or four million bacteria per cubic centimeter may be
rded as exceptionally good for European cities. No general aver-
of American cities can be made, but the probability is that the
supply delivered in our large cities, by the free use of ice, is in
eral superior to that of the milk supply of European cities. The milk
rge cities contains more germs than that of small communities, but
obably no more harmful.

## KINDS OF DAIRY BACTERIA.

nsiderably over two hundred distinct types of ordinary milk bac-
have been described in literature up to the present time, and all
hese will be found, in the descriptions given, to differ from each
r. Most of them have been named or numbered by the persons who
ribe them. They have been found in various dairy products, in
milk, in old milk, in butter, cream, and cheese.

Some produce very pleasant flavors in the milk and crea
produce decidedly unpleasant flavors; some of them are e
troublesome to the milkman, but favorable to the butter mak
are troublesome wherever they appear. In short, the effect
ferent bacteria upon milk is extremely varied, so that the
fermentation are almost as numerous as kinds of bacteria th

### THE SOURING OF MILK.

When an acid, as acetic acid (the acid of vinegar), is added t
milk curdles, and we have the phenomenon of sour milk. Po
may be said that in the common souring of milk organisms in
act upon its constituents, notably the milk sugar, and produ
acids, which give the milk a sour taste and curdle the casei
the milk thick. Commonly, lactic acid is the principal aci
although smaller quantities of a number of other acids usual
pany it. Hence the normal souring of milk is spoken of
fermentation. While the spontaneous souring of milk is a
universal phenomenon, it is not always produced by the sam
very closely allied organisms. Occasionally the milk in a larg
of dairies in one locality will be found to be soured by the sam
of bacteria, while in other cases the spontaneous souring ma
duced by different species in dairies at no great distance fr
other. Sometimes, indeed, this spontaneous fermentation is
Certain herds of cattle have been noted whose milk does not
will after a time undergo other types of fermentation. It is al
that not infrequently in the winter months milk is found not to
the souring spontaneously, but may be kept for a long time
curdling, and when it does show signs of fermentation the
entirely different from that of normal milk souring.

It is probable that the decomposition of milk may take p
number of different ways. While we are certain that the ferm
of milk, commonly known as souring, is caused by bacteria,
yet much to learn regarding the details of the process.

### SUPPOSED EFFECT OF THUNDERSTORMS ON THE SOURING

A consideration of the subject of the souring of milk woul
complete without reference to the effect of electricity. The
belief that thunderstorms will sour milk is so widespread that
seem as if there must be some foundation for it. It has been
by many that the ozone produced in the air by electricity ca
milk to become sour. In experiments in which electric sparks
charged over the surface of the milk, however, little or no e
been produced upon it. The conclusion is that electricity is not
capable of souring milk or even of materially hastening the
Nor can the ozone developed during the thunderstorm be look

as of any great importance. It seems probable that the connection between the thunderstorm and the souring of milk is one of a different haracter. Bacteria certainly grow most rapidly in the warm, sultry onditions which usually precede a thunderstorm, and it frequently hap- ens that the thunderstorm and the souring occur together, not because he thunder has hastened the souring, but rather because the climatic onditions which have brought the storm have at the same time been uch as to cause unusually rapid bacteria growth. This fact has been erified by many experiments which have shown that without the pres- nce of lactic organisms there can be no spontaneous souring of milk. Milk deprived of bacteria will certainly keep well during thunder- torms. Dairymen find no difficulty in keeping milk if it is cooled mmediately after being drawn from the cow and is kept cool. Milk ubmerged in cool water is not affected by thunderstorms. Dairymen nd that during "dog-day" weather, even when there is no thunder, it is ust as difficult to keep milk as it is during thunderstorms; and they lso find that scrupulous cleanliness in regard to the milk vessels is the est possible remedy against souring during a thunderstorm. It is safe conclude, therefore, that in all cases it is the bacteria which sour the ilk, and if there seems to be a casual connection between the thunder d the souring it is an indirect one only; climatic conditions have has- ned bacteria growth and have also brought on the thunderstorm. he same conditions would affect the milk in exactly the same way en though no thunderstorm were produced, and this effect, our dairy- en tell us, is frequently observed during the warm, sultry autumn days.

### OTHER FORMS OF FERMENTATION OF MILK.

Students have not recognized until within recent years that a great riety of fermentations may occur in milk. The reason for the tardi- ss of this discovery is easily seen. Under ordinary conditions milk ays undergoes some sort of lactic fermentation (souring). Only der rare conditions is this absent. The production of lactic acid soon dles the milk and immediately obscures all other forms of fermenta- n which have occurred during the process. The acid also stops the wth of all bacteria, so that no subsequent effect can be seen. Hence normal milk clear evidence of fermentation of any other sort than ring is rarely noticed.

The later studies of this subject, however, have shown the great variety form of organisms in milk, and the many different results of their ion. Thus, while one class of organisms, as we have seen, curdles k by the production of lactic acid, another class gives it an alkaline tion, at the same time curdling it; others impart to it a deep blue, et, yellow, green, or red color by the production of pigments in the k; others give it a bitter or other unpleasant taste; another class duces alcohol from the milk sugar, which fact is taken advantage of

in the preparation of such beverages as koumiss and kefir,
others cause putrefaction. Some of these forms of fermentatio
briefly noticed:

### BUTYRIC ACID FERMENTATION.

The characteristic of this fermentation is the production of
acid. In the ordinary handling of the milk this class of orga
of little importance, but it has been supposed that they
important effect upon the keeping properties of butter. Ranci
contains considerable quantities of butyric acid, and the deve
of the rancidity is simultaneous with the appearance of the
acid. When it became known that many species of bacteria
butyric acid and that there are many bacteria in butter, i
natural inference that the rancidity is produced by them. It is
that the ordinary rancidity of butter is the result both of ferm
and chemical oxidation, although rancidity may occur when
are entirely absent.

### ALKALINE FERMENTATION OF MILK.

The fermentation of milk is not always accompanied by the
tion of an acid. Everyone who has had an extended experie
milk has seen instances of milk curdling without the usual ac
and it is a familiar fact that curdled milk is by no means co
character. There is the greatest variety in the stiffness of t
the amount of the whey, the taste, odor, etc., and all these di
are due to varying numbers and species of bacteria other t
lactic acid class.

The milk may become coagulated into a soft, slimy mass, wh
ally possesses a bitter taste. The taste is never sour, and t
instead of having an acid reaction, is either alkaline or neutral
a day or two the curd begins to dissolve into a somewhat clea
and, if the action is allowed to continue long enough, may beco
pletely dissolved into a semitransparent liquid having no rese
to milk.

In the ordinary handling of milk the class of organisms includ
this head of alkaline ferments is of little importance. They grow
and the lactic-acid-forming species usually get the start of th
ducing their own marked effect on the milk, so that the actio
alkaline species is entirely obscured. Moreover, the acid-formin
soon produce so much acid that the growth of all bacteria is
At the same time these species are of the greatest importance
matters. In the first place, many of them form resisting germ
will endure high temperature and render the process of sterili
by heat very difficult. They are always present in milk which
standing for a short time, and sometimes their abundance
enough to produce noticeable effects.

### SLIMY FERMENTATION.

slimy fermentation of milk is a somewhat common occurrence, occasionally produces great trouble in dairies, since it destroys the k for all ordinary uses. Slimy milk will furnish no cream. It can be churned, and it is ruined for drinking purposes. Slimy fermen- on, however, is made use of in the manufacture of Edam cheese.

here has been the greatest variety of theories as to the cause of y milk. Diseases of the mammary gland, variations in the food of cow, and differences in conditions surrounding the dairy have all e in for a share in the explanation. But the slimy fermentation of k has been found to be connected with a large variety of organisms. e of them give to the milk only a slight sliminess, while others ren- it tenacious almost beyond belief. One, described by Conn, renders k so slimy that it can be drawn into threads 10 feet long and so ll as to be hardly visible. Some of the organisms render milk slimy heir early growth, others only after several days, and some do not ler the fresh milk slimy at all, but first curdle it and then dissolve curd into slimy solution.

### BLUE MILK.

his fermentation, characterized by the deep blue color which has n it its name, occurs sometimes as an isolated trouble in individual ies, and sometimes it has become so prevalent in certain localities as e almost an epidemic. The explanation now given for blue milk is a ble one. Ordinary milk contains some of the lactic acid organisms, these, acting in connection with another species of bacteria, pro- e the brilliant blue color which characterizes this infection. When ving in ordinary milk the effect of this organism is very marked. a few hours no change is noticed, but just about the time when the begins to become acid some intense blue patches make their appear- . The faster the acid forms the quicker the coagulation appears the smaller are the blue patches, while if the acid is produced more ly the blue patches are larger and of a better color.

here the blue-milk organism comes from is unknown, nor have we knowledge of the causes of the occasional epidemics of blue milk. e can be little doubt that the cause is always some unknown ce of filth. In some cases the trouble has been traced to a single cow large dairy, and has been easily stopped by isolating the individual d to be the cause, or by carefully washing the cow's teats with a weak acetic acid solution. Blue milk is always an infection due tside contamination, and its remedy is always to be found in care cleanliness. It does not occur in the carefully kept dairy.

ue milk appears to be harmless. It has been fed to animals, which t readily and without harm. Within a few years blue cheese has brought to the attention of scientists, and has been attributed to ame organism which produces the trouble in milk.

### BITTER MILK.

Several organisms have been described which impart a bitter to milk. Recently two new forms have been isolated from bitter cl and bitter cream. The bitter taste appears to be due to the produ of a special bitter substance produced by the organisms. This stance has been isolated, but its nature is not definitely known. I instance bitterness in milk was produced in a whole herd by feedi the cattle turnips which had been washed in foul water. Whether i due directly to the turnips or to the water in which they were wa was not ascertained, but the conditions were such as to point pl to microorganisms as the direct cause.

### SOAPY MILK.

A type of dairy trouble called soapy milk has been recently desci The milk frothed badly, failed to sour, and had a soapy taste. I a troublesome infection, rendering the cream difficult to churn practically destroying its value. It was traced to bacteria on the used for bedding the cows. The trouble ceased after the straw discarded. Another case of soapy milk was traced to the hay, on the same bacteria were found as on the straw.

### FERMENTATION OF MILK BY RENNET.

Rennet is a preparation usually made from the stomach of a cal has the power of coagulating the casein of milk in a very short This curdling of milk by rennet is the only form of fermentati milk known which is produced by an unorganized ferment; i. e. devoid of life.

When rennet is added to milk, a portion of the nitrogenous con ents of the milk is thrown down, and forms the curd which is into cheese. Another portion, being soluble, goes into the whey is lost to the cheese maker. The amount of protein thus lost ma still further increased through the action of bacteria, which hav power of making even curdled casein soluble; and this fact teache advisability of using rennet in a manner which will produce the co lation as quickly as possible. The rapidity of the action will de upon the relative amount of rennet and the temperature, and ma lessened by alkalies and increased by various salts.

The active principle of rennet is a chemical ferment which is dis from other digestive ferments in the stomach juices. It is destr by a temperature of 158° F., and it acts best at about 95° F. It s to be somewhat widely distributed in nature among animals and pl and it is a common product of bacteria growth. Milk bacteria ducing the rennet-like curdling are abundant, and their share in ordinary fermentations of milk is not a small one, especially in weather. In the keeping property of butter they doubtless play a though they are not the sole cause of rancidity. In the ripeni cream for churning their part is still greater, and in the ripening of cheese they are of the utmost importance. Undoubtedly we may trace many of the difficulties of the butter and cheese maker to bacteria of this class. A further knowledge of their action will be of great value to the dairy interest.

### PRACTICAL BEARING OF THE SUBJECT UPON DAIRYING.

It is becoming more and more evident every year that the bearing of these fermentations upon dairying is of the utmost importance. The practical application of our knowledge of the fermentations of milk will concern each of the three chief dairy products—milk, butter, and cheese.

#### HANDLING OF MILK.

To those dealing with milk itself in any form the various fermentations are especially undesirable and are constant sources of trouble. Such persons want the milk pure and sweet, and any of the various forms of fermentation injure the milk for their purposes. Our study of milk fermentations has taught us that the cause of all these fermentations, even the common souring, lies in the contamination of the milk from without, and that the remedy lies in the exercise of extreme cleanliness. If there has been anything taught in regard to these matters it is the extreme necessity for cleanliness. Poor milk, poor butter, and poor cheese are, in a vast majority of cases, to be attributed to uncleanliness in the barn or dairy. The great source of bacterial contamination of the milk is *the cow herself*. This does not mean the bacteria from the mammary gland, but those connected with the exterior of the cow. It is true that there are other sources of importance. The food that the cow eats (indirectly), the cow stall itself, the water with which the cans are washed or with which the milk is adulterated, the hands of the milker as well as his clothes, are all occasionally the sources of bacteria contamination. But after all we must look upon the cow herself as the cause of the most trouble. From the cow the bacteria get into the milk during the milking, partly from the milk ducts, partly from the dirt that is attached to the cow, and in no small measure from her dung. We thus learn that the important point toward which to direct the cleanliness is the cow herself. The farmer never appears to feel that it is necessary for him to keep his cows as clean as he does his horse. But there is very much more real need for cleanliness in the case of the cow. Upon such cleanliness will depend his ability to obtain a pure, wholesome milk, while so sure as he allows his cow to become covered with dirt and manure so sure will he be liable to have trouble with the milk. So it is well to repeat that the last few years have taught us, above all things, that the great secret of obtaining a proper supply of milk is to have a *healthy cow and to keep that cow clean.*

Another fact of importance which has been emphasized is the value of cooling the milk as thoroughly as possible as soon as milked. When drawn from the cow, milk is at a high temperature, and, indeed, at just the temperature at which the majority of bacteria will grow the most rapidly. Under the influence of the atmospheric temperature, especially in the summer, the milk will become cool very slowly, but never becomes cooler than the air. The bacteria which have gotten into the milk will therefore have the very best opportunity for rapid multiplication and the milk will sour very rapidly. If, however, the milk is cooled to a low temperature immediately after it is drawn, the bacteria growth is checked at once and will not begin again with much rapidity until the milk has become warmed once more. This warming will take place slowly, and therefore the cooled milk will remain sweet many hours longer than that which is not cooled. A practical knowledge of this fact will be of great value to every person handling milk. Early cooling to as low a temperature as is practicable is the best remedy for too rapid souring of milk.

It is well to notice that certain abnormal odors and tastes in milk may be produced directly by the food eaten by the cow. If a cow eats garlic or turnip the flavor of the milk is directly affected. Various other foods may, in a similar manner, affect the taste of milk, but this class of taints may be readily distinguished from those due to bacteria growth. The odors and taints due to the direct influence of the food are at their maximum as soon as the milk is drawn, never increasing afterwards. But the taints due to bacteria growth do not appear at all in the fresh milk, beginning to be noticeable only after the bacteria have had a chance to grow. If, therefore, a dairyman has trouble in his milk, which appears immediately after the milking, he may look for the cause in something the cow has eaten. But if the trouble appears after a few hours, and then grows rapidly worse until it reaches a maximum, he may be assured that the cause is some form of fermentation, and that the remedy is to be sought, not in changing the food of the cow, but in greater care in the management of the dairy or barn.

*Dairy inspection.*—In this connection the desirability of an inspection of the dairies and herds furnishing milk for cities and towns may be mentioned. Our laws have furnished us with a milk inspection which protects our pocketbooks, but we are learning that the adulteration of milk by water is really of far less importance to the public in general than the contamination of the milk by improper types of microorganisms. We have learned, as already pointed out, that milk is occasionally contaminated with disease germs, such as tuberculosis, typhoid fever, diphtheria, scarlet fever, etc., but that such organisms come only from cases of disease, either diseased cattle, which directly contaminate the milk, or diseased persons, who indirectly are a source of such contamination. There is no need of milk becoming contaminated by any of these disease germs, with a possible exception of tuberculosis, if care utiny is used by the milk producer to prevent the milk from d cattle being distributed, and to prevent its being placed under ons for secondary contamination from diseased persons.

all these facts in mind, it becomes plain that the proper precaution against the evils resulting from such contamination found in some system of dairy inspection, by means of which lic may have a direct knowledge and direct control over the ons of its milk supply. Already such a dairy inspection in one another has been attempted in several places. In some other it is being demanded by State boards of health.

hief advantage in such dairy inspection is to the milk producer. tzerland and in the United States the plans started with the en. Of course the advantage is also largely to the public com-, but the producer of the milk will in the end gain the greatest age in increased confidence which the public may have in his t. At the present time the public is rapidly becoming suspicious healthful qualities of our milk supply, and just so far as this on can be allayed by the inauguration of a proper dairy inspec-st so far will the milk industry be benefited.

### BUTTER MAKING.

the custom of butter makers to allow their cream to "sour," or ," for a number of hours before churning. This is accomplished wing it to stand in a warm place for twelve to twenty-four As it is everywhere recognized to-day, the ripening of cream is a matter of bacteria growth, and whether the cream is ripened in er (normal) or in an improper (abnormal) manner depends upon mber and kinds of bacteria that chance to be in it at the begin- the ripening.

ng the number of kinds of bacteria found in the cream there w species whose growth in the cream produces there a pleasant, le aroma and flavor. These species are seemingly fewer in num-n the others, but it is to their presence that a good butter is due, is with little doubt largely the presence of these species in June and their absence in January cream that gives June butter a flavor than winter butter. Now, the butter maker in ripening am will always produce in it a certain amount of acid from the rganisms, and even if he has no proper flavor-producing species t the butter that he obtains will be a moderately good product, ed he does not happen to have any of the mischievous species t. He knows well enough that during certain seasons in the year obtain a butter that has no very bad taste, and yet that does ve the desirable flavor. No method at his disposal will enable these times to give his butter the flavor he desires. Under such ons his cream is affected with the neutral class of bacteria, while vous ones are absent as well as the desirable flavor-producing

By proper care in barns and dairies the mischievous specie in general kept out of the cream. By the use of cleanly me the cow stall and dairy we may depend upon the milk and cr taining a small quantity of bacteria and only wholesome ones.

Conn has found that winter cream and June cream contain a bacteria flora in the same creamery; that the species of bacter ferent creameries differ at identical dates; that the species fr a creamery by different patrons differ, and that, in short, the l flora of the creamery is undergoing constant change. It is, of largely a matter of luck whether the cream at a given creamery at a certain time to have the high flavor-producing species pre

To eliminate this factor of luck from the ripening of cream p tures have been prepared in laboratories of the bacteria that s give the desired flavor and aroma to cream, and these cultur been used in practical experiments. When inoculated into th they sour it rapidly and produce at the same time a desirable The use of these organisms has extended from the laboratorie they started, in Denmark and in Germany, and at the pres they are used somewhat widely in European countries. In oth forms of bacteria have been selected which impart a desirabl and aroma without materially aiding in souring the cream. case the lactic organisms commonly present in the cream are reli for giving it the desired acidity. An organism isolated by Co named by him Bacillus No. 41, has given very promising resu has been adopted in a number of creameries for ripening the In the use of Bacillus No. 41 a large culture of the organism i directly to the ordinary cream, and the ripening is carried on a The result has been that the souring is delayed, and the ripeni be continued longer and thus the flavor be improved, and a no better product is obtained. The peculiar effect of this organism to be to add to the butter a flavor which the butter maker desc a "quick grass" flavor, such as he looks for in June butter. Th is not much affected. The pleasant flavor appears to be added butter in all conditions in which the experiments have thus f made. It has been tried upon poor cream and upon good crean fresh cream and stale cream; upon separated cream and upon cream; in creameries of the very highest character and creame very much lower grade, and the verdict in all the cases has be form. Wherever it has been added to the cream for ripenin proper way there has been an improvement in the quality of the made in the individual creamery. The butter of a poor cream not, indeed, been brought up to the quality of gilt-edged butter has been improved; and even the gilt-edged butter of our highe creameries has been pronounced better after the use of this bac the ripening of its cream. Indeed, up to the present time it ha chiefly the better creameries which have adopted its use.

re is very little doubt that the ripening of cream by pure cul-
of bacteria is sure to become more popular, for they make it pos-
for the butter maker to obtain uniformity all the year round.
the acid ferments and Bacillus No. 41 are now put up in such
hat they can be readily distributed to the creameries of the coun-
Their use is rapidly growing, and in the opinion of some of our
utter makers it will not be long before it will become almost
sal.

## CHEESE MAKING.

acteria are desirable allies of the butter maker, they are abso-
ecessities to the cheese manufacturer. Without their agency in
ng cream, the butter, though it may taste flat, is still usable, but
is worthless without them. New cheese is not palatable; it
like fresh milk curd, and is not at all pleasant. The proper flavor
ese appears only as a result of a ripening process which is allowed
tinue for several weeks or months, the flavor slowly growing
er all the while. This ripening is the result of the action of bac-

It is customary to recognize the normal ripening and the abnor-
pening of cheese, although no very sharp line of distinction can
wn between the two. The normal ripening of cheese is the one
roduces a good marketable product, and the abnormal ripening
ormal product.

*ormal ripening.*—Up to the present time we have very much
knowledge of the types of abnormally ripened cheese than of
lly ripened cheese. In the last few years very many such cheeses
been studied. It is a well-known fact that such abnormally
d cheeses make their appearance in almost all cheese factories.
imes as high as 50 per cent of the cheeses made in a factory are
less, or comparatively worthless, from the results of abnormal
ng. Many investigators have been studying the various types
iled cheese for the purpose of discovering the cause of the trouble.
most common type of abnormally ripened cheese is one in which
is a large accumulation of gas, chiefly carbonic acid, but some-
ammonia or free nitrogen. This accumulation of gas causes the
to swell and produces large cavities. In another special form of
lar infection, known as "Nissler" cheese, the cheese is filled with
erable small holes. This abnormal swelling has been found to be
ced by certain species of bacteria or yeasts growing in the cheese,
develop a superabundance of gas. Some twenty-five species of
rganisms up to this time have been definitely proved to be the
of such an abnormal swelling of cheese, including both bacteria
easts. It would appear, however, that much depends upon the
ions in the cheese and the numbers of the organisms present. It
ainly true that some of these species may be present in small
ty in the cheese and it will ripen normally, while if they are
t in large quantities there will be an abnormal swelling of the

cheese. The sources of the organisms in this long list are of c variable. One important source is the organisms that come from suffering from udder inflammations. Other sources may be in s lots of hay, or they may come from sources that are entirely unk So varied appear to be the bacteria that no general directions can given for avoiding them, and so little do we now know of the conditions that very little can be done to remedy the trouble.

Other types of abnormally ripened cheese that have been st are red cheese, blue cheese, black cheese, bitter cheese, and pois cheese. In the last case the cheese becomes impregnated with sonous ptomaine (tyrotoxicon), produced by organisms as yet e unknown. In short, all the types of abnormally ripened cheese are distinctly recognized in the cheese factory have been studie practically all of them at the present time have been traced origin in certain microorganisms.

Studies of the bacteria in normally ripened cheese have consis the examination of the bacteria in the cheese at intervals in the ing from the first day until the time the cheese is fully ripen appears that the multiplication of bacteria in cheese is compar slow. In cream during its ripening the bacteria multiply with prod rapidity, increasing perhaps six hundredfold to a thousandfold twenty-four hours. In cheese, however, while for some weeks th teria do increase in number, the increase is very slow. In one c increase was found of about sixtyfold in eighty-five days; in a about 160-fold in twenty-eight days. After a time, moreove increase in bacteria comes to an end, and later the number of isms present in a living, active condition becomes less and less finally, at the end of the ripening, the number is very much les it was during the middle of the ripening period, sometimes c down to nearly the original number. There are, however, great i larities. At times the multiplication appears to be very much g and more rapid than at others; sometimes the number present at a stage of the ripening is ten times as great in one specimen as i another, even though the latter had the larger number to start w

As for the species of bacteria present, this, too, undergoes co change during the ripening. At the beginning the number of s may be considerable, depending, of course, upon the number original milk from which the cheese was made. But as the ri continues the number decreases, and finally, at the end of the ing, in many cases there has been left a single species or a very number of species. Some species originally in the milk disapp once and can have no share in the ripening process.

Whether the normal ripening and the flavor of properly ri cheese is due to a single species in each kind of cheese, or to th bined action of several, or whether it may not be produced by a m of different species equally well, as in the case of the butter fla ot at present know. There is a growing belief that the flavor of rent types of cheese is due to different species of bacteria, and when we have mastered the problem we shall be able to produce given type of cheese by simply inoculating the milk with the er quantity of definite species of bacteria. But this belief is at ent based upon general inferences, and not upon demonstrated . The fact that such definite types of abnormally ripened cheese be produced by inoculating the milk with certain species of bac- shows the great influence of bacteria. The fact that a given ity will produce a uniform product of cheese for a long time indi- that this locality has probably become impregnated with a cer- species of microorganism. Moreover, it is known that when a cheese factory is started precautions are frequently taken to carry of the cheese from an old factory to the new one, and to rub the shelves and vats and the other appurtenances in the fac- with the old cheese, in order to infect it with the proper ripening nisms.

ny species of bacteria are known to produce desirable cheese rs when growing in milk. In some cases the use of pure cultures been adopted in cheese making, although not from the bacte- gical standpoint. One method of making Edam cheese consists oculating the milk with a slimy whey, which has been found to in a very nearly pure culture of a slimy organism. These facts ate that the cheese ripening is the result of distinct specific germs, what they are or how large a variety we do not at present know. e sources of cheese bacteria are more variable than the sources of eria in ripening the cream. Of course we have in the first place y organisms in the milk which is brought to the cheese factory, but ldition to this the cheese is inoculated with organisms from several r sources. The cheese vats and the various apparatus used in the se factory are a prolific source of organisms. The water that ed in the manufacture of cheese is an important source. More rtant than any of these is the rennet which is used to curdle the n. Recent studies of rennet have shown that the number of bac- in it is very great, especially in certain forms of rennet. The et added to the milk in considerable quantities is thus a direct lation of the milk with a large number of bacteria. It has long recognized that it makes considerable difference in the character e cheese whether one or another kind of rennet is used for curdling, after we have recognized that the various types of ripening are to different kinds of bacteria, we see at once that the addition of et to the milk is to be regarded as an inoculation of the cheese h will result in a vast modification of its ripening. This agency e bacteria rennet in the ripening of cheese is only just beginning recognized, and is a subject upon which much work needs to be .

We have, in short, at the present time an insufficient knowledge o the ripening of cheese to enable us to control the process. We can t a certain extent avoid some types of abnormal ripening by the following simple method: If cheese ripens abnormally it will probably b due to the milk from one patron being impregnated with an unfavorabl species of bacteria. By use of a simple apparatus samples of milk o each patron may be set by themselves and allowed to ferment spontaneously. After two days an examination of the samples, a study o the odor, the taste, and the amount of gas produced enables the chees maker to judge somewhat accurately whether the milk is safe to put i his cheeses. If there is a superabundance of gas, or if very vile odors are produced, the milk of the patron in question should be excluded from the cheeses. Of course it takes a day or two to apply this test, but this is a matter of no very great importance in the cheese factory, because the farm that is furnishing an improper species of bacteria one day will probably continue to do so for the season. A method of preventing the abnormal swelling of cheese has been suggested by Freudenreich; i. e., the salting of the milk. When the trouble appears in a cheese factory all the subsequent cheeses may be treated as follows: After the milk has curdled, about two-thirds of the whey is removed and salt is added to the rest to the extent of 3 per cent. The cheese is then made as usual, although a smaller quantity of salt must be put into it in the end. This use of salt has been found in some cases to be quite efficient in preventing the abnormal swelling. Another method of remedying the abnormal swelling, also based upon bacteriological knowledge, has sometimes been found to be useful. When the cheese begins to show signs of this abnormal production of gas it is at once cooled to a very low temperature, either by putting it into a cold cellar or, if the cheese is a large one, by the use of ice. This lowering of the temperature at once stops the fermentation which is going on, and if the cheese is kept at this temperature for some time the milk sugar will gradually undergo such changes that when subsequently the temperature is increased the fermentation will not recommence. Beyond these facts, however, little of practical importance to the cheese maker has as yet resulted from bacteriological study.

In guiding the milk producer to the best method of furnishing pure milk, in aiding the butter maker in obtaining a uniform and desirable flavor, and in helping the cheese maker to avoid some of his difficulties dairy bacteriology has already done much. In the immediate future we can see further practical results. To the dairy interest the bacteriologist holds out the hope of uniformity. The time will come when the butter maker may always make good butter and the cheese maker may be able in all cases to obtain exactly the kind of ripening that he desires.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 30.

# RAPE DISEASES

ON THE

# PACIFIC COAST.

BY

NEWTON B. PIERCE,
DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1895.

## LETTER OF TRANSMITTAL.

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U. S. Department of Agriculture,
Division of Vegetable Physiology and Pathology,
*Washington, D. C., July 16, 1895.*

Sir: I have the honor to transmit herewith Farmers' Bulletin No. 30, rape Diseases on the Pacific Coast, prepared by Mr. Newton B. Pierce, sistant in this Division. The bulletin brings together in a brief, practal way the main facts in regard to three of the principal diseases fecting the grape in California and other Pacific Coast States.

Respectfully,

B. T. Galloway,
*Chief of Division.*

Hon. Chas. W. Dabney, Jr.,
*Acting Secretary of Agriculture.*

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# GRAPE DISEASES ON THE PACIFIC COAST.

## INTRODUCTION.

More than one-half the grapes of the United States are grown on the Pacific Coast, California alone having approximately 200,000 acres of vines. Most of the varieties grown in this region are derived from a single species of grape, *Vitis vinifera*, which is believed to be a native of Asia, but which has been so long and so extensively cultivated throughout Europe that it has become widely known as the European vine. The varieties in the eastern United States have, for the most part, originated from native North American species, but will grow under almost all the different climatic conditions prevailing in this country.

The root louse (*Phylloxera*), and the fungous diseases known as downy mildew, powdery mildew, and black rot are much more severe on European than on native varieties. *Phylloxera*, so common upon our wild vines, where its injuries are slight, becomes a deadly parasite when transplanted to the roots of the European grape. The older vineyards of France have been largely destroyed by this pest, but are now being restored by grafting the tender European varieties upon the roots of hardy wild vines obtained from the United States. Powdery mildew (*Oidium*) and downy mildew (*Peronospora*), which do little damage to our native vines, have swept over European vineyards like fire. One reason why the cultivated European vines are more susceptible to the enemies mentioned than American species is probably owing to the long cultivation and continued selection of the more fruitful rather than the more hardy European varieties, the result naturally being a stock of high-bred but tender plants.

From the preceding remarks it will be seen that the main reason why vine diseases are more destructive on the Pacific than on the Atlantic Coast is because the European or tender varieties are grown in the former and the American or hardy vines in the latter part of the United States

## CALIFORNIA VINE DISEASE.

Several vine diseases occur on the Pacific Coast which cause heavy losses. The most serious one, however, is the California vine disease, which has already killed more than 30,000 acres of the most thrifty productive vineyards. This disease may be placed among the mo destructive as well as the most obscure of all plant maladies. Co sidering its injurious nature, the obscurity of its cause, and the exte of its ravages, it may be classed with peach yellows. For a centu prior to the appearance of this disease in the localities where it no prevails, the most susceptible Mission varieties had been grown with t greatest success. As near as can be learned, the disease first appear in 1884; in 1885 many vines were killed, and in 1886 extensive vineyar were destroyed by it in the vicinity of Anaheim, Cal. From this tim on the disease spread, until now whole vine-growing regions a denuded and the disease is at work 50 miles from the point where i began its ravages. Up to the present time, as before stated, 30,00 acres of vines have been destroyed, causing a direct and indirect los of not less than $20,000,000.

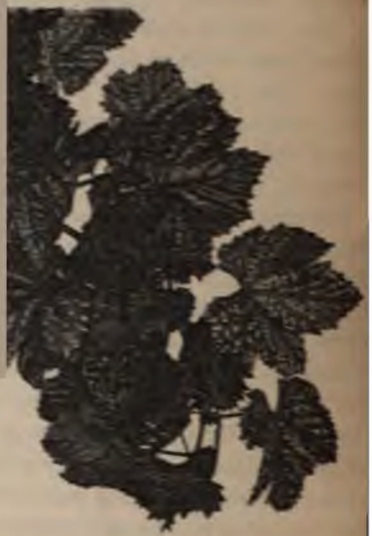

FIG. 1.—Leaves of Muscat of Alexandria attacked by the California vine disease.

The effects of the disease are seen the first season on the foliage the vine, but by the second season a reduced growth of the cane i apparent. Taking the Muscat of Alexandria as an illustration of th behavior of the disease, when the leaves of this variety are attacke small yellow spots appear in the tissue between the main veins; as the spots enlarge they often unite, forming yellow strips, which broade and die at the center (fig. 1). Eventually there is a well-marked brow stripe of dead tissue, bordered by yellow on each side, leaving only narrow band of green tissue along the veins. After this the leaves fal and as a result the immature portions of the canes turn black and di The next season the growth is short. Often the color of the foliage nal in the spring, becoming spotted during the heat of summer, r which the premature fall of the leaves and the death of the es ensue as before. The following spring the vine may fail to put h new growth, or it may grow until the heat of the summer and n die. This is a typical illustration of the progress of the malady, ich works in many ways. In some instances the diseased vines ear perfectly healthy up to the time of the vintage, when they sud- ly die; in other cases they live from three to five years.

he roots also show the diseased state of the vine at an early period; growing points shrink and the rootcap begins to decay. This ay is most apparent in the parenchyma or soft tissue surrounding wood bundles of the smaller roots. The soft parts rot to such an nt that the cortical portion of the root may be easily stripped from wood. This decay progresses until nearly the whole root system is lved.

hen the malady first appears in a vineyard its attacks seem spo- c. The disease will show on a vine here and there or on several s in one section of the vineyard where some unfavorable soil con- n weakens the stocks. Gradually other vines become affected, and disease continues to progress and its virulence becomes more ked, until finally the vineyard is worthless.

me varieties of vines are much more resistant to the California dy than others, but there is no variety, so far as observed, which wholly withstand it. Wild vines growing in the mountain can- have been killed by it, and the Eastern vines appear to be only ially resistant, many of them succumbing to the disease. The dif- ice in the hardiness of varieties has often been shown in a striking ner. The Mission vine is one quite easily affected; the Muscat, on ontrary, yields more slowly to the disease. When the malady first ared there were thousands of acres of fine Muscat and Mission yards in the region around Anaheim; in the immediate neighbor- l of Anaheim chiefly Mission grapes were planted, which were used naking wine. Scattered among the wine vineyards, however, were erous vineyards of raisin grapes of the Muscat of Alexandria ety. It was remarked by all that the disease at first killed only wine or Mission grapes, the raisin grapes remaining apparently thy. So marked was the destruction of the wine grapes and the rent immunity of the raisin grapes that many regarded the disease judgment on the wine traffic. However, the year after the disease ared among the Mission grapes the raisin grapes showed disease in the end the raisin growers were no better off than the wine ers.

udies of this malady have revealed the fact that cuttings from ased vines are themselves diseased, and that the degree or amount isease in the cutting is proportionate to the degree or stage of the ase in the parent vine. Cuttings from diseased vines may root well and produce a fine, healthy-looking top, especially in the spring, b as the heat of the season approaches these young vines show disea dying earlier or later, according to the length of time the pare vine has been affected. The disease is also found to be cumulative its action. The longer the vine lives the more obvious becomes unhealthy condition, the vitality of the plant being gradually overcon

When the disease was most virulent it was learned that vines gro from healthy cuttings procured from outside of infected districts wou also contract the malady and die. As time passed, however, it lo much of this virulence, and the setting of healthy cuttings can now recommended with more confidence than formerly. Numerous vi yards are growing and bearing well which were started from healt vines, while the disease is still apparent in many vineyards set fr cuttings procured within the infected district. To those who conte plate planting new vineyards within the infected district it may of value to know that the vineyards of the great San Joaquin Vall can be recommended as a convenient and proper source of supply healthy cuttings. Cuttings should not be obtained within the limits the infected district unless made from young vines grown from healt stock.

### POWDERY MILDEW.

Powdery mildew is one of the most common fungous diseases of t vine. It is present in nearly all the grape-growing countries of t world, but is most destructive in warm and humid localities, for instance, near the sea. In California it was known as early as 1860 1861, and is now present in most of the vineyards along the coast. T fungus grows on the canes, the leaves, and the fruit; its greatest inju however, is done to the latter, as it checks the growth of the ber either entirely or on one side, the parts affected becoming hard. Wh one side only is attacked the further growth of the berry causes t dried surface to burst open, wholly destroying the fruit.

Powdery mildew has two kinds of reproductive bodies or spores, for rapid summer distribution and the other to preserve the fungus o winter. In the warmer portions of the Pacific Coast the summer spo are the only ones commonly observed. When abundant they giv whitish, powdery appearance to the parts of the host affected, and i from this appearance the fungus derives its name. These white su mer spores are called conidia. The winter fruits are produced on approach of cold weather, and, unlike those of summer, are thick-wall blackish bodies, securely inclosing and protecting the delicate spor They are more or less abundant according to the climate where the v is grown.

This disease can be easily treated, owing to the fact that the vi portions of the fungus grow upon the surface, making possible the of remedies as well as preventives. A fungicide may be applied af the vine is affected and still serve to check the progress of the disease. Sulphur is the agent used in nearly all cases, the fumes destroying the tender spores and vegetative organs. Throughout the warmer valleys of the coast it is the practice of some growers to place the sulphur upon the hot ground at the windward side of the vines. The heat of the sun causes the fumes to rise and pass through all portions of the vine above ground. Other growers scatter the dry sulphur upon the crown of the vine by means of loosely woven sacks or from the perforated bottoms of tin cans, two rows of vines being sulphured at once by a man passing between them. In districts subject to the disease it is found desirable to apply the sulphur once before the grapes are in bloom and again when the fruit is set. The vineyard should be sulphured as often as the mildew begins to appear to an injurious extent. No definite rule for treatment can be laid down, as seasons vary and the vines are much more subject to the disease in some localities than in others.

In the treatment of vines trained long and not pruned back, as is the common practice on the Atlantic Coast, an early spring spraying of the vines with bordeaux mixture may aid in keeping down this mildew, as it will prevent the infection of new growth from the winter spores remaining upon the vine. This early spring spraying will also aid in preventing the infection of the vine by spores of other fungi.

## COULURE.

The word coulure is taken from the French, and signifies the falling of grape flowers and the imperfect growth of grapes. It is a trouble in which the vine growers of the entire country, especially those of the Pacific Coast, are deeply concerned. The causes of coulure are many, and some which exist on the Pacific Coast are not commonly found in the Eastern States. The greatest and most frequent losses from this disease occur in the raisin-growing districts of California and Arizona, and arise mostly from climatic causes. It has caused much greater damage in raisin than in wine vineyards. This is true both in California and Arizona, and in Arizona it is said a full first crop of raisin grapes has not been obtained for twelve years or more. The total loss to the coast from coulure can not be accurately estimated, but it certainly amounts to many millions of dollars.

There are two varieties of raisin grapes proper grown in California. The oldest variety is the Muscat of Alexandria. It is the standard and is probably the highest-bred raisin grape in existence. It has the softest and most beautiful foliage of any vine, and the flavor of its fruit is the standard by which all raisin grapes are estimated. It bears the name of one of its ancient homes, Alexandria, in Egypt, where it was cultivated at least two thousand years ago and where possibly it may have originated. The other variety of raisin grape extensively grown in California is the Muscatel Gordo Blanco (fig. 2), a variety originally brought from Spain and very closely allied to the Muscat of dria. It is probable that this is only a seedling of the Musc somewhat more hardy than the parent plant.

An examination of the situation in the raisin districts of C especially in the San Joaquin Valley, showed that the droppi fruit was due in the main to unfavorable climatic conditions a the time when the first-crop grapes were in bloom. Both th of Alexandria and the Muscatel Gordo Blanco varieties are bred and so tender that cold or other unfavorable climatic c will prevent the fecundation of the flowers. Both are prolifi but owing to sudden changes of temperature, cold weather, winds, which are not i when the first crop grape bloom, it is not uncommon than one-half of the bloo to set fruit, as shown in fig loss which this causes is The first-crop bunches are the largest and bear the f first-ripening grapes, henc are injured or lost it causes reduction in the output of and at the same time lo quality. It is, in fact, the bunches which raise the g price by making the Londo Further than this, the grapes ripen much earlier second crop, and hence may in the sun before the fall r

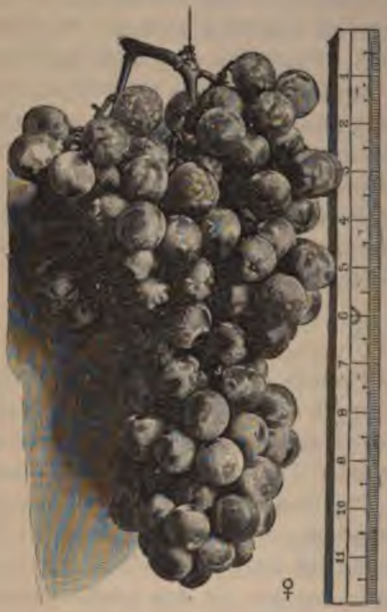

FIG. 2.—Bunch of Muscatel Gordo Blanco grapes.

To save the first crop grapes from injury is ther important problem. As t injury is done when they are in bud and bloom, that period i with which we have to deal. As a result of investigations it w tained that if the first bloom could be delayed until the weathe fine the injury would not occur, and that if protected from th from other unfavorable atmospheric conditions the crop could These facts indicate that it is the tenderness of the plant whic it subject to injury. To overcome this weak point in the two mentioned, the writer, in the spring of 1893, commenced a ser periments in crossing these varieties with the Malaga. This C Malaga is a vine of exceedingly thrifty growth and is hardy out. Its root system will support the vine in sandy soils, w Muscat would die. Its leaves are heavy and large, and the hoppers does not cause them to fall, as is the case with the Muscat, re no grapes are allowed to sunburn, a source of large losses. ther than this, the fruit makes an exceedingly good raisin, though equal to the Muscat or Muscatel. The bunches are large and ost wholly first crop, and the berries are of good size. The vine ays sets a full bunch. Besides the qualities above mentioned, the laga is free from coulure; its entire strength goes to the first-crop nches, the bunches and berries are large and of good quality; the or is light; and the vigor and bit of growth, both of root d top, are all that could be sired.

The work of Millardet and e Grasset has shown that in osses among vines the variety species used for pollination is e one transmitting its hardi- ss, hence in the experiments ndertaken in crossing the Ialaga and Muscat the Malaga as chosen as the pollinating ariety.

Arrangements were made ith Mr. L. S. Chittenden, of e Lucerne vineyard, Hanford, al., to furnish the vines re- ired for the work, and to sist in the growing of the edling vines when the cross as made. The facilities ten- red by Mr. Chittenden and e other owners of this vine- rd could not be surpassed. he first cross was made in the pring of 1893 between the Ialaga and Muscatel. Many undreds of Muscatel flowers ere emasculated and polli- ated with Malaga pollen. The cross was effective and several hundred rtile seeds were obtained. These were sown with care in the spring 1894 and at present a number of plants are being reared. The work the spring of 1894 was still more extensive, between 16,000 and 20,000 ape flowers being emasculated and cross-pollinated. The crossing as not confined to two varieties only, but several of the most desira- e combinations were made, and at this writing the grapes are properly aturing.

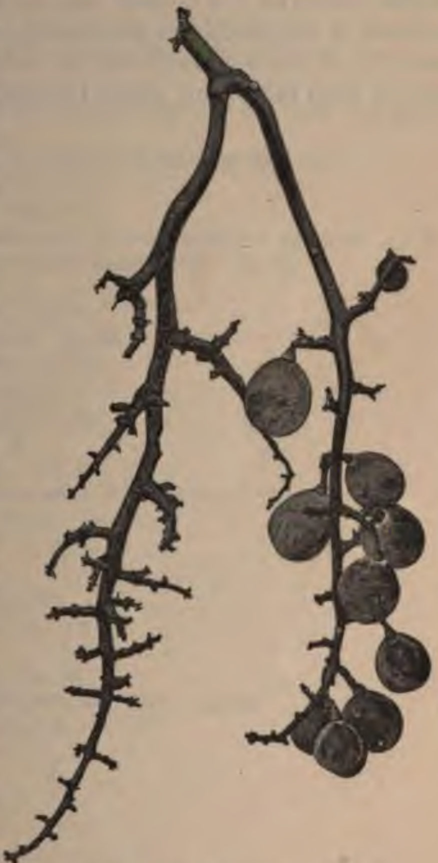

FIG. 3.—Bunch of grapes showing effects of coulure.

It is our purpose to obtain as large a number of these crossed vines as possible, and when grown to maturity to select those plants which inherit in the desired degree the hardiness of the Malaga and the fruiting qualities of the Muscat, Muscatel, and other varieties used in the crosses. That this will ultimately do away with the losses from coulure in raisin grapes is confidently believed, and it is doubtful if there be any other satisfactory way out of the trouble.

It will require several years to grow the new seedlings to maturity, but the results of the crosses may be hastened somewhat by grafting the wood of the seedlings into mature vines. In this manner the ultimate fruit of the seedlings may be obtained at an earlier date than it could be from the young plants themselves.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 34.

# ATS: COMPOSITION AND COOKING.

BY

CHAS. D. WOODS,
OFFICE OF EXPERIMENT STATIONS.

[Corrected February 17, 1904.]

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GOVERNMENT PRINTING OFFICE.
1904.

# LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
*Washington, D. C., October 12, 1895.*

Sir: I have the honor to transmit herewith, for publication as a Farmers' Bulletin an article on the composition and cooking of meats, prepared under the immediate direction of Prof. W. O. Atwater, special agent in charge of nutrition investigations by Mr. Chas. D. Woods, vice-director of the Storrs (Conn.) Experiment Station, and attached to this Office as an expert for nutrition investigations. This bulletin summarizes the results of investigations regarding the nutritive value of different kinds of meat, and points out some of the things which should be considered in the cooking of meats for different purposes. The table appended to this article is based upon all the available data regarding the composition and fuel value of American meats (exclusive of fish), and is believed to be more complete than any similar table hitherto published.

Respectfully,

A. C. True,
*Director.*

Hon. J. Sterling Morton,
*Secretary.*

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# MEATS: COMPOSITION AND COOKING.

## ANIMAL AND VEGETABLE FOODS COMPARED.

The food of man can not be healthful and adequate unless it supplies the proper amount of the different nutritive ingredients, or "nutrients." Practical experience proves this, and experimental inquiry demonstrates it as well. Just what the functions of the different foods are—their "nutritive value and cost"—has been discussed in Bulletin No. 142 of this series, and a knowledge of the facts there set forth is necessary to a clear understanding of the present bulletin.

It is natural to divide foods into two classes—animal food and vegetable food. Not only is this division simple and convenient, as pointing out the two great sources of man's food, but the classification is a true one, for the difference between animal and vegetable food is very striking in appearance, composition, and value in the economy of life. It is true that many of the chemical compounds which enter into the composition of these two classes of food are either alike or quite similar; but in general the vegetable foods contain large amounts of carbohydrates—such as sugar, starch, woody fiber, etc.—while the animal foods, and meat in particular, contain only small amounts of these carbohydrates. As regards the fats and nitrogenous matters or "protein," the case is reversed; for vegetable foods have comparatively little of these two classes of nutrients, while meats have relatively very large amounts.

The value of meats as food, therefore, depends on the presence of two classes of nutrients, protein and fat. The protein is essential for the construction and maintenance of the body. Both protein and fat yield muscular power and maintain the temperature. It is possible to combine the fat of animal foods with the protein so as to meet the requirements of the body without waste, but the vegetable foods contain nutrients more especially adapted for the production of energy.

Another difference between animal and vegetable foods is in digestibility. The compounds contained in the animal foods ar course, very much like those of our bodies, and therefore need but change before they are ready for use. The vegetable compound the other hand, require much greater changes before they can be as lated. They are less readily and less completely digested thar animal foods. This is due in part to the fact that the nutrien vegetable foods are often inclosed in cells with woody walls, resist the action of the digestive fluids, and in part to the action woody fiber in irritating the lining of the intestine, and thus hast the food through the intestine before the digestive juices have ti act thoroughly upon the food. Indeed, the presence of the woody frequently prevents the complete digestion and absorption not o the nutrients contained in the vegetable foods, but also of those tained in the animal foods eaten at the same time.

## STRUCTURE OF MEATS.

In the sense in which the word is here used, meat consists o muscular tissue, or lean, and the varying quantities of fat whic found in the different parts, as between and within membranes and dons. Besides the fat ordinarily visible there is always present or less of fat in particles too small to be readily distinguished fro lean which surrounds it. These particles can, however, be re obtained by chemical methods in quantities sufficient to be seen weighed.

The lean part of meat has practically the same final structure re less of its kind and its muscular tissue. All muscular tissue is up of prism shaped bundles, which can be divided into smalle smaller bundles, until finally the muscle fibers or tubes are rea These irregular tubes are so small that they are invisible to the na eye. They vary in diameter from $\frac{1}{200}$ to $\frac{1}{1100}$ of an inch.

These muscle fibers or tubes are held together in bundles by m of connective tissue, and the invisible fat is stored between and i the different fibers and bundles of fibers. Each of the bundl muscle fibers, seen when a piece of meat is cut "across the grain in a round steak, is made up of hundreds of the muscle tubes.

The envelope or wall of each tube is a very delicate, elastic m brane, composed of nitrogenous material. The walls themselve quite permanent, but their contents are continually undergoing ch and renewal.

## COMPOSITION OF MEATS.

As regards composition, the meats found in the markets cons the lean or muscular tissue, connective tissue or gristle, fatty ti blood vessels, nerves, bone, etc. No general statement can be made with regard to the proportion in which these substances occur, as it is found to vary greatly with the kind of animal, with different "cuts" from the same animal, and with many other conditions.

### REFUSE, AS BONE, SKIN, ETC.

Nearly all meats bought and sold in the markets contain some portions not suitable for eating, which may properly be designated as refuse. Some of these, as bone, contain some nutriment, and may be utilized to a greater or less extent in making soups, and perhaps in some other ways; but for the most part they are thrown away.

It is important to distinguish between refuse and "waste." As the term is ordinarily used, any portion considered unsuitable for eating would be designated as refuse. At another time or under other conditions, it might be desirable to use for food the portion which was before considered useless. Such portions, therefore, are not refuse in the proper meaning of the term. They are waste. Some parts of meat, however, from their lack of nutrients or from the impossibility of preparing them for food, are and always will be useless, and these portions we may properly call refuse. As population increases there is, however, an increasing tendency to utilize portions of meats which have hitherto been thrown away. If our classification is to be a true one, therefore, we must narrow the use of the term "refuse" from its generally too-broad application and must cover much of its popular meaning by the term "waste." The skin of fish and poultry, "rind" of pork, case of sausages, etc., are illustrations of materials which might by one person be classed as refuse and by another be considered edible and thus be classed as waste if they were rejected at the table.

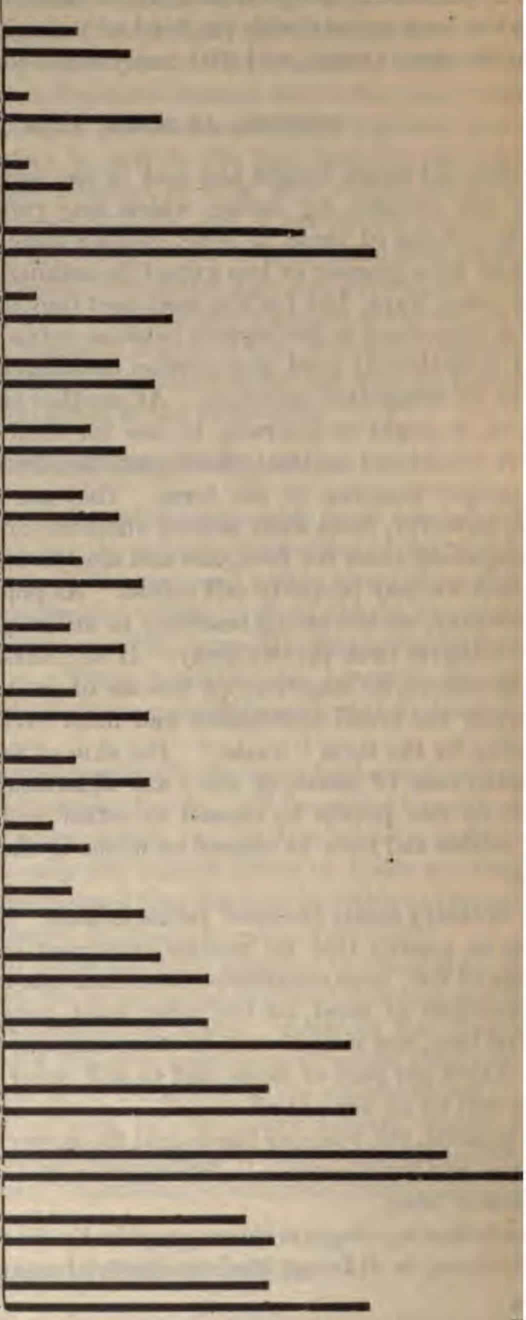
In ordinary meats the chief refuse is bone. The percentage of bone varies so greatly that no precise statement can be made. In many species of fish, bone constitutes more than one-half the dressed weight. In some cuts of meat, on the other hand, notably the round of beef, slice of ham, and similar cuts in other animals, there may not be more than 2 or 3 per cent of bone, and in still other cuts, as shoulder clod, there will be no bone at all.

In general, the younger the animal the larger the relative proportion of bone, and with increase in fatness there is a relative decrease in the amount of bone.

The following diagram shows graphically the variations in the refuse, chiefly bone, in different kinds and cuts of meats.

*The smallest and largest percentages of refuse found in different kinds and cuts of m*

| Kind of meat. | Percent. | Comparative scale. |
|---|---|---|
| Beef: | | |
| Side | from 12 | |
| | to 21 | |
| Sirloin | from 4 | |
| | to 26 | |
| Round | from 4 | |
| | to 11 | |
| Hind leg (shank) | from 50 | |
| | to 62 | |
| Shoulder and clod | from 5 | |
| | to 28 | |
| Veal: | | |
| Side | from 19 | |
| | to 25 | |
| Chops | from 14 | |
| | to 20 | |
| Cutlet | from 13 | |
| | to 19 | |
| Mutton: | | |
| Side | from 13 | |
| | to 23 | |
| Chops | from 11 | |
| | to 20 | |
| Leg | from 12 | |
| | to 24 | |
| Pork: | | |
| Chops | from 12 | |
| | to 24 | |
| Smoked ham | from 8 | |
| | to 14 | |
| Halibut steak | from 11 | |
| | to 23 | |
| Cod | from 26 | |
| | to 34 | |
| Mackerel | from 34 | |
| | to 58 | |
| Shad | from 44 | |
| | to 59 | |
| Oysters, in shell | from 74 | |
| | to 88 | |
| Long clams, in shell | from 40 | |
| | to 45 | |
| Lobster, in shell | from 44 | |
| | to 61 | |



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## WATER.

Meats contain large and varying amounts of water. For the pur-
ses of mastication, swallowing, etc., of course this is better than if
e meat were dry; but the water contained in flesh has no greater
lue as food than other water. From this it follows that the greater
e amount of water in a given weight of food the less is its relative
utritive value, for it will contain a less quantity of nutritive material.
ish and oysters have relatively more water than most other meats.
n general, the greater the amount of fat in a given cut the less is the
amount of water. For instance, a lean cut of beef may have 75 per
cent of water, while a fat cut from the same animal may not contain
more than 50 per cent.

The diagram on page 8 illustrates the variations in the quantity of water in the edible portions of different kinds and cuts of meats.

## FATS.

All meats contain some fat, partly stored in quantities so large as to be readily seen, and partly distributed in such small particles that it is only by chemical means that it can be obtained in quantities sufficient to be appreciated. In the flesh of some animals, as cod and other white-meated fish, and in chicken (young fowl), rabbit, and veal, there is little or no visible fat. In a very fat ox, on the other hand, one-fourth of the weight of meat may be visible fat, and, in the case of fat hogs, more than half the weight may be fat. No flesh is so lean as not to contain at least minute portions of fat. Very lean flesh, as dried beef, may not have more than 3 per cent of fat, while fat pork may contain more than 90 per cent.

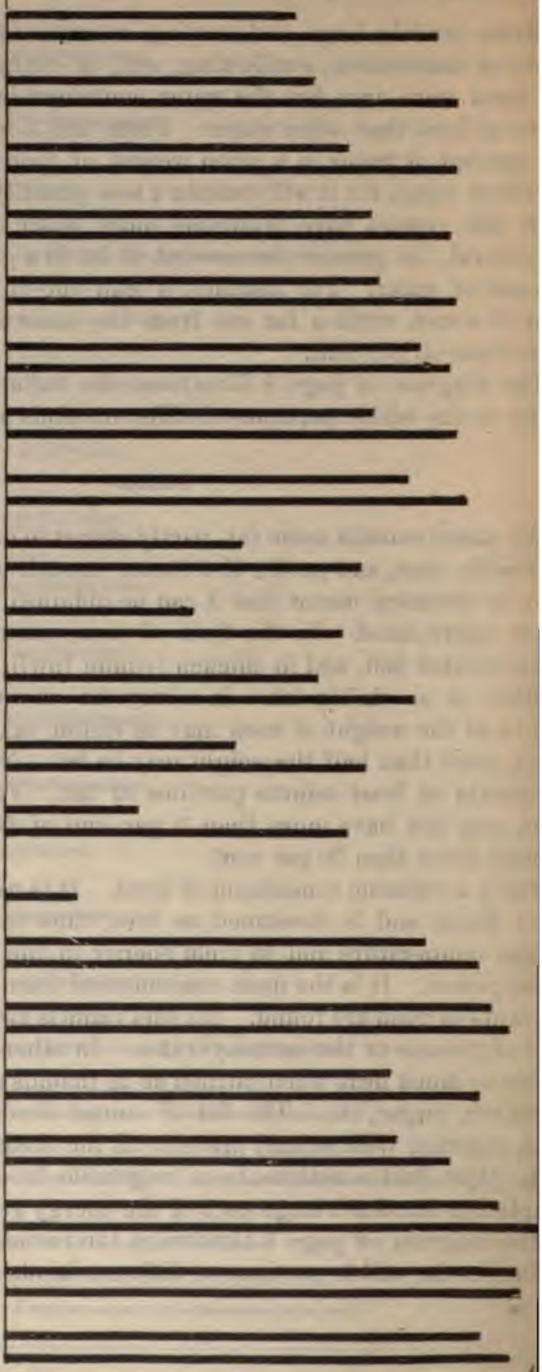
Fat is a valuable constituent of food. It is used in the body to form fatty tissue and is consumed as fuel, thus serving to maintain the animal temperature and to yield energy in the form of muscular and other power. It is the most concentrated form in which the fuel constituents of food are found. Its fuel value is two and one-fourth times that of protein or the carbohydrates. In other words, 1 pound of fat yields as much heat when burned as 2¼ pounds of carbohydrates, such as starch, sugar, etc. The fat of animal foods might be so supplied that, together with animal protein, all the needs of the body could be met. The fuel constituents of vegetable foods are, however, better adapted to furnish a large part of the energy required by the body.

The diagram on page 9 illustrates the variations in the percentage of fats in the edible portions of different kinds and cuts of meats.

*The smallest and largest percentages of water found in the edible portion of diffe kinds and cuts of meat.*

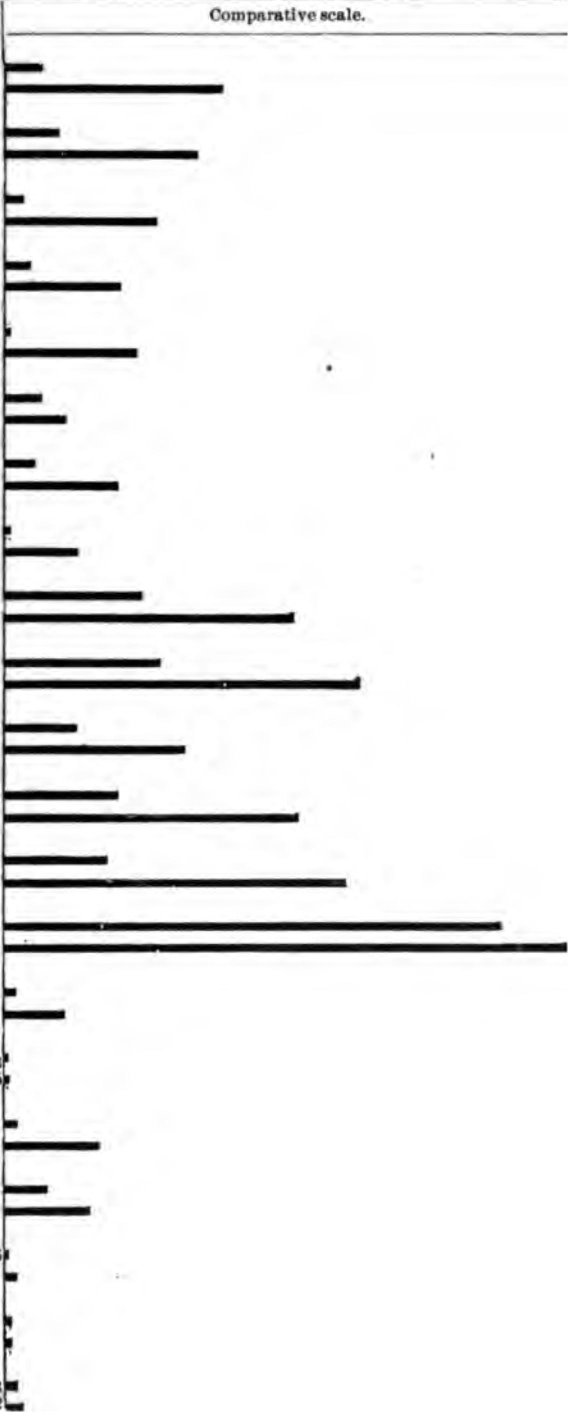
| Kind of meat. | | Per cent. |
|---|---|---|
| **Beef:** | | |
| Side | from | 48 |
| | to | 72 |
| Sirloin | from | 51 |
| | to | 75 |
| Round | from | 57 |
| | to | 75 |
| Hind shank | from | 61 |
| | to | 74 |
| Shoulder and clod | from | 62 |
| | to | 75 |
| **Veal:** | | |
| Side | from | 69 |
| | to | 74 |
| Chops | from | 61 |
| | to | 75 |
| Cutlet | from | 67 |
| | to | 77 |
| **Mutton:** | | |
| Side | from | 39 |
| | to | 59 |
| Chops | from | 31 |
| | to | 56 |
| Leg | from | 52 |
| | to | 68 |
| **Pork:** | | |
| Chops | from | 38 |
| | to | 60 |
| Smoked ham | from | 22 |
| | to | 57 |
| Fat, salt | from | 0 |
| | to | 12 |
| **Halibut steak** | from | 70 |
| | to | 79 |
| **Cod** | from | 81 |
| | to | 84 |
| **Mackerel** | from | 64 |
| | to | 79 |
| **Shad** | from | 65 |
| | to | 74 |
| **Oysters** | from | 82 |
| | to | 91 |
| **Long clams** | from | 85 |
| | to | 86 |
| **Lobster** | from | 79 |
| | to | 84 |

Comparative scale.



*e smallest and largest percentages of fat in the edible portion of different kinds and cuts of meat.*

| Kind of meat. | Per cent. | |
|---|---|---|
| eef: | | |
| Side | from | 6 |
| | to | 36 |
| Sirloin | from | 9 |
| | to | 32 |
| Round | from | 3 |
| | to | 25 |
| Hind shank | from | 4 |
| | to | 19 |
| Shoulder clod | from | 1 |
| | to | 22 |
| Veal: | | |
| Side | from | 6 |
| | to | 10 |
| Chops | from | 5 |
| | to | 19 |
| Cutlet | from | 1 |
| | to | 12 |
| Mutton: | | |
| Side | from | 23 |
| | to | 48 |
| Chops | from | 26 |
| | to | 59 |
| Leg | from | 12 |
| | to | 30 |
| Pork: | | |
| Chops | from | 19 |
| | to | 49 |
| Smoked ham | from | 17 |
| | to | 57 |
| Fat, salt | from | 83 |
| | to | 94 |
| Halibut steak | from | 2 |
| | to | 10 |
| Cod | from | .3 |
| | to | .5 |
| Mackerel | from | 2 |
| | to | 16 |
| Shad | from | 7 |
| | to | 14 |
| Oysters | from | .6 |
| | to | 2 |
| Long clams | from | 1 |
| | to | 1 |
| Lobster | from | 3 |
| | to | 2 |



## NITROGENOUS CONSTITUENTS (PROTEIN).

There are a great many kinds of nitrogenous compounds in flesh, and an almost hopeless confusion exists in their classification and in the names assigned to the various classes by different chemists. Chemists are quite generally agreed, however, in designating the total nitrogenous substance as protein. These compounds containing nitrogen may be arranged in the following three groups or classes:

PROTEIN:

*Albuminoids*, as albumen (white of eggs); casein (curd) of milk; myosin, the basis of muscle (lean meat); gluten of wheat, etc.

*Gelatinoids*, as collogen of tendons and ossein of bones, which yield gelatin or glue, etc.

*Nitrogenous extractives.*—Meats and fish contain very small quantities of so-called extractives. They include creatin and allied compounds, sometimes called meat bases, and are the chief ingredients of beef tea and meat extract.

The nitrogenous compounds of meats are made up chiefly of albuminoids and gelatinoids. The albuminoids are so called because they resemble albumen or white of egg in their properties, and the gelatinoid substances are so named because of their similarity to gelatin. They are easily changed into gelatin by the action of hot water or steam, as in the manufacture of gelatin and glue from bones.

The value of meats as food is chiefly due to the nitrogenous compounds which they contain, and of these the most valuable are the albuminoids. This is due to the fact that they are very similar in composition to the nitrogenous compounds of the body, and are therefore easily digested and assimilated. Experiments with sheep, swine, dogs, and other animals seem to show that feeding rich, nitrogenous foods considerably increases the percentage of albuminoids in the flesh.

Very different views have been held at different times as to the value of gelatin as a food. At one time it was considered nearly as valuable as the albuminoids themselves; but later, from the investigations of the "French Gelatin Commission," it fell into disrepute and was held to have almost no food value. Later and better conducted experiments, however, have demonstrated that gelatin, when combined with albuminoids and extractives, has a very considerable nutritive value and serves to economize the albuminoids.

The last class, known as nitrogenous extractives, or meat bases, are so called because of the ease with which they may be dissolved out (extracted) by water. They are formed by the decomposition (cleavage) of albuminoids and probably gelatinoids. They consist largely of creatin and creatinin, substances which somewhat resemble thein and caffein, the active principles of tea and coffee. They are of little value as food, but they give flavor to meats, and are therefore of great importance. They will be referred to again when we come to consider the flavor of meats, soups, and meat extracts.

The lean of meat has, in round numbers, about 20 per cent of protein, or, weight for weight, about five times as much as milk. The flesh wls, especially wild fowl, has on the average more protein than , and the flesh of fish has less.

hile protein is the most important and valuable ingredient of food, flesh is, nevertheless, a one-sided diet, and to make a well-balanced n for man the addition of foods containing carbon, such as fat, hes, sugar, etc., is necessary.

e diagram on page 12 illustrates the variations in protein in the e portions of different kinds and cuts of meats.

## CARBOHYDRATES AND ASH.

though carbohydrates occur in considerable quantities in other s, flesh contains but a small amount—only a fraction of 1 per —and that chiefly in the form of glycogen, or muscle sugar. In of the organs, notably the liver, there are considerable quantities ycogen.

ats also contain more or less of mineral matters (ash) which have as food. The most important of these are the phosphates of h, lime, and magnesia. These are used chiefly in the formation ne.

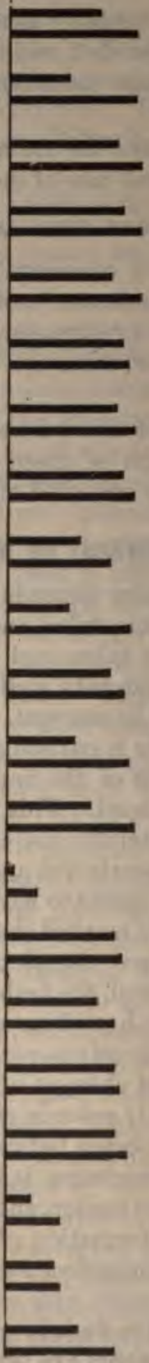
## TEXTURE (TOUGHNESS) OF MEATS.

hether meats are tough or tender depends upon two things—the cter of the walls of the muscle tubes and the character of the ective tissues which bind the tubes and muscles together. In g and well-nourished animals the tube walls are thin and delicate, the connective tissue is small in amount. As the animals grow , or are made to work (and this is particularly true in the case of y nourished animals), the walls of the muscle tubes and the con- ve tissues become thick and hard. This is the reason why the of young, well-fed animals is tender and easily masticated, while esh of old, hard-worked, or poorly fed animals is often so tough rolonged boiling, or roasting, seems to have but little effect on it.

ter slaughtering, meats undergo marked changes in texture. These es can be grouped under three classes or stages. In the first , when the meat is just slaughtered, the flesh is soft, juicy, and quite r. In the next stage the flesh stiffens and the meat becomes and tough. This condition is known as *rigor mortis* and continues the third stage, when the first changes of decomposition set in. t climates the meat is commonly eaten in either the first or second . In cold climates it is seldom eaten before the second stage, and ally, in order to lessen the toughness, it is allowed to enter the stage, when it becomes soft and tender, and acquires added flavor. oftening is due in part to the formation of lactic acid, which acts the connective tissue. The same effect may be produced, though rapidly, by macerating the meat with weak vinegar. Meat is times made tender by cutting the flesh into thin slices and pound- across the cut ends until the fibers are broken.

*The smallest and largest percentages of protein in the edible portion of di*
*and cuts of meats.*

| Kind of meat. | Per cent. | | Comparative scale. |
|---|---|---|---|
| Beef: | | | |
| Side | from | 15 | |
| | to | 21 | |
| Sirloin | from | 10 | |
| | to | 21 | |
| Round | from | 18 | |
| | to | 22 | |
| Hind shank | from | 19 | |
| | to | 22 | |
| Shoulder clod | from | 17 | |
| | to | 22 | |
| Veal: | | | |
| Side | from | 19 | |
| | to | 20 | |
| Chops | from | 18 | |
| | to | 21 | |
| Cutlet | from | 19 | |
| | to | 21 | |
| Mutton: | | | |
| Side | from | 12 | |
| | to | 17 | |
| Chops | from | 10 | |
| | to | 20 | |
| Leg | from | 17 | |
| | to | 19 | |
| Pork: | | | |
| Chops | from | 11 | |
| | to | 20 | |
| Smoked ham | from | 14 | |
| | to | 21 | |
| Fat, salt | from | 1 | |
| | to | 5 | |
| Halibut steak | from | 18 | |
| | to | 19 | |
| Cod | from | 15 | |
| | to | 18 | |
| Mackerel | from | 18 | |
| | to | 19 | |
| Shad | from | 18 | |
| | to | 20 | |
| Oysters | from | 4 | |
| | to | 9 | |
| Long clams | from | 8 | |
| | to | 9 | |
| Lobster | from | 12 | |
| | to | 18 | |



## FLAVOR OF MEATS.

The toughness or tenderness of meat, as has been stated above, is dependent upon the walls of the muscle tubes and the connective tissue. The flavor, however, depends largely upon the kinds and amounts of "nitrogenous extractives" which the tubes contain. Pork and mutton are deficient in extractives, and what flavor they possess is due largely to the fats contained in them. The flesh of birds and of most game is very rich in extractives, which accounts for its high flavor. In general the flavor of any particular meat is largely modified by the condition of the animal when slaughtered, and by its food, age, breed, etc. We have seen that the flesh of young animals is more tender, but it is also true that it is not so highly flavored as that from more mature animals. In most cases, also, the flesh of males is more highly flavored than that of females. There are two exceptions to this rule. The flesh of the goose is more highly flavored than that of the gander, and in the case of pork there is little difference between the flesh of the male and that of the female. Castration, as illustrated in the familiar example of the capon, makes the flesh more tender, fatter, and better flavored.

With the exception of fish, the flesh of animals which feed exclusively upon fish or flesh has a strong, disagreeable taste, and is eaten only by uncivilized people or those in great need. As regards ordinary meat, however, it is enough to say that the nitrogenous extractives, and hence the flavor, depend mainly upon the age of the animal and the character of its food.

Meat which is allowed to hang and ripen develops added flavors. In the first stages of decomposition compounds quite similar to the nitrogenous extractives are formed, and it is to these that the added flavors are due. Game is sometimes allowed to hang until the decomposition changes have gone so far as to be offensive to one whose taste is not educated to enjoy the flavor of "high" meat.

## DIGESTIBILITY OF MEATS.

We must remember that, as in the case of other foods, the value of meats does not depend entirely upon the amount of nutrients which they contain, but to some extent upon the amount of these nutrients which the body can digest and use for its support. Digestion proper consists of the changes which the food undergoes in the digestive tract, where the digestible portion is prepared to be taken up by the blood and lymph. These changes are chemical processes, and we can determine quite readily by experiment how much of each nutrient will be digested, but this line of research is new and the methods are not yet perfectly matured.

Comparatively little attention has been given to the percentages o the different meats which are digested; but the facts so far obtai seem to indicate that flesh of all kinds, either raw or cooked, is quite completely digested by a healthy man. Rubner found that when given in quantities of not more than 2 pounds per day all but 3 per cent of the dry matter of roasted beef was digested by a healthy man. From other experiments roasted flesh seems to be rather more *completely* digested than either raw or boiled meat, but raw meat is more *easily* digested than cooked (boiled or roasted).

A far larger number of experiments and observations have been made upon the digestive processes which pertain to the stomach than upon complete digestion. This is partly due to the hygienic importance of stomach digestion (for a large part of the digestive disorders occur in the stomach) and partly to the ease with which observations of stomach digestion can be made. Much is said about "ease of digestion," by which is usually meant the rapidity with which certain foods pass out of the stomach into the intestine, where the principal work of digestion actually takes place. Roast chicken and veal are tender, easily masticated, well flavored and appetizing, and, so far as the stomach or gastric digestion is concerned, are easily and rapidly digested. This agrees with the practice of using the so-called "white meats" in diets for the sick room. The rapidity of gastric digestion of this class of foods is due to the tenderness of the muscular tissues, and to the fact that this kind of meat contains almost no fat. Fat meats, as beef and mutton, are much less quickly passed out of the stomach, and gastric digestion in the case of fat pork is especially difficult. Although gastric digestion is important, it is by no means a measure of the digestibility of a food.

The question of the digestibility of food in the broad sense is a very complex one, and there is much room for investigation in this field of research in learning the quantities of nutrients which are digested from different kinds of meats, in studying the effects of cooking, in determining the influence of different substances and conditions upon digestion, and in the study of numerous other questions. Until these investigations and experiments shall have been made, it will not be possible to affirm much more about the digestibility of meats than the simple but important statement that nearly all the protein and about 95 per cent of the fats are digested by the average person.

## THE COOKING OF MEATS.

Uncivilized man differs from civilized man in no more striking way than in the preparation of food. The former takes his nourishment as it is offered by nature; the latter prepares his food before eating, and in ways which are the more perfect the higher his culture.

Meat is rarely eaten raw by civilized people. For the most part it is either roasted, stewed, fried, or boiled. Among the chief objects of cooking are the loosening and softening of the tissues, which facilitates igestion by exposing them more fully to the action of the digestive uices. Another important object is to kill parasites, and thus render armless organisms that might otherwise expose the eater to great risks. Minor, but by no means unimportant, objects are the coagulation of the albumen and blood so as to render the meat more acceptable to the sight, and the development and improvement of the natural flavor, which is often accomplished in part by the addition of condiments.

Flavoring materials and an agreeable appearance do not directly increase the thoroughness of digestion, but serve to stimulate the digestive organs to greater activity. As regards the actual amount digested, this stimulation is probably not of so great moment as is commonly supposed. Meat that has been extracted with water so as to be entirely tasteless has been found in actual experiment to be as quickly and completely digested as an equal weight of meat roasted in the usual way.

In general, it is probably true that cooking diminishes the ease of digestion of most meats. Cooking certainly can not add to the amount of nutritive material in meat; and it may, as we shall see, remove considerable quantities of the nutrients.

## BOILING.

If it is desired to heat the meat enough to kill parasites or bacteria in the inner portions of the cut, the piece must be exposed to the action of heat for a long time. Ordinary methods of cooking are seldom sufficient. In a piece of meat weighing 10 pounds the temperature of the interior, after boiling four hours, was only 190° F. The inner temperature of meat when roasting has been observed to vary from 160° to 200° F., according to the size of the piece. In experiments upon the canning of meat it was found that when large and even small cans were kept for some time in a salt-water bath at a temperature considerably above the boiling point of water, the interior temperature of the meat rose to 208° in some cases and only 165° in others. Large cans of meat are more liable to have bad spots than smaller cans, because the heat in them is not sufficient to destroy the bacteria or other organisms that cause the meat to decompose.

If meat is placed in cold water, part of the organic salts, the soluble albumen, and the extractives or flavoring matters will be dissolved out. At the same time small portions of lactic acid are formed, which act upon the meat and change some of the insoluble matters into materials which may also be dissolved out. The extent of this action and the quantity of materials which actually go into the solution depend upon three things—the amount of surface exposed to the water, the temperature of the water, and the length of the time of the exposure. The smaller the pieces the longer the time, or the hotter the water the richer will be the broth and the poorer the meat. If the water is heated gradually, more and more of the soluble materials are dissolved. At a temperature of about 134° F. the soluble albumen will begin to coagulate, and at 160° F. the dissolved albumen will rise as a brownish scum to the top, and the liquid will become clear. Upon heating still higher, the connective tissues begin to be changed into gelatin, and are partly dissolved out, while the insoluble albuminoids are coagulated. The longer the action of the hot water continues, the tougher and more tasteless the meat becomes, but the better the broth. Treated in this way flesh may lose over 40 per cent by weight. This loss is principally water, but from 5 to 8 per cent may be made up of the soluble albumen, gelatin, mineral matters, organic acids, muscle sugar, and flavoring materials. Part of the melted fat also goes into the broth.

It would be a great mistake to assume that the nearly tasteless mass of fibers which is left undissolved by the water has no nutritive value. This tasteless material has been found to be as easily and completely digested as the same weight of ordinary roast. It contains nearly all the protein of the meat, and, if it is properly combined with vegetables, salt, and flavoring materials, makes an agreeable as well as nutritive food.

If a piece of meat is plunged into boiling water or very hot fat the albumen on the entire surface of the meat is quickly coagulated, and the enveloping crust thus formed resists the dissolving action of water and prevents the escape of the juices and flavoring matters. Thus cooked, the meat retains most of its flavoring matters and has the desired meaty taste. The resulting broth is correspondingly poor.

The foregoing statements will be of much help in the rational cooking of meats in water. The treatment depends largely upon what it is desired to do. It is impossible to make a rich broth and have a juicy, highly flavored piece of boiled meat at the same time. If the meat alone is to be used, the cooking in water should be as follows: Plunge the cut at once into a generous supply of boiling water and keep the water at the boiling point, or as near boiling as possible, for ten minutes, in order to coagulate the albumen and seal the pores of the meat; the coating thus formed will prevent the solvent action of the water and the escape of the soluble albumen and juices from the inner portions of the meat. But if the action of the boiling water should be continued, the whole interior of the meat would, in time, be brought near the temperature of boiling water, and all the albumen would be coagulated and rendered hard. Instead of keeping the water at the boiling point (212° F.), therefore, the temperature should be allowed to fall to about 180° F., when the meat could be thoroughly cooked without becoming hard. A longer time will be required for cooking meat in this way, but the albumen will not be firmly coagulated, and the flesh will be ıder and juicy instead of tough and dry, as will be the case when e water is kept boiling, or nearly boiling, during the entire time of ɔking.

In boiling sections of delicate fish, as salmon, cod, or halibut, the ınging into boiling water is objectionable because the motion of the lling water tends to break the fish into small pieces. Fish should be t put into water that is on the point of boiling. The water should kept at this temperature for a few minutes and then allowed to fall 180° F., as in the case of meats.

## STEWING.

f both the broth and the meat are to be used, the process of cooking uld be quite different from that outlined for boiling meat. Stewing n this country a much undervalued method of cooking. This is bably due partly to the fact that stewing is generally very improp- y done, and partly to the general aversion which Americans, con- ɔusly or unconsciously, have to "made dishes" of any kind. This rsion probably has its origin in a false notion which spurns economy ıny attempt at economy in diet.

n stewing, the meat should be cut into small pieces, so as to present ıtively as large a surface as possible, and, instead of being quickly nged into hot water, should be put into cold water in order that ch of the juices and flavoring materials may be dissolved. The perature should then be slowly raised until it reaches about 180° where it should be kept for some hours. Treated in this way, the th will be rich and the meat still tender and juicy.

f the water is made much hotter than 180° F. the meat will be dry fibrous. It is true that if a high temperature is maintained long ugh the connective tissues will be changed to gelatin and partly olved away, and the meat will apparently be so tender that if shed with a fork it will fall to pieces. It will be discovered, how- r, that no matter how easily the fibers come apart, they offer con- rable resistance to mastication. The albumen and fibrin have ɔme thoroughly coagulated, and while the fibers have separated n each other the prolonged boiling has only made them drier and ıer.

## BROTHS, SOUPS, MEAT EXTRACTS.

he quantities of the ingredients in a meat broth may be illustrated German experiment. One pound of beef and 7 ounces of veal bones e about a pint of strong broth or soup, which contained, by weight: ter, 95.2 per cent; protein, 1.2 per cent; fat, 1.5 per cent; extract- , 1.8 per cent; and mineral matters, 0.3 per cent.

ery palatable broths can be made by using more water and adding ry herbs. Broths thus made have, of course, a greater amount of er, frequently as much as 98 per cent, or even more, and the nutrients are correspondingly reduced in amount. It would appear from the analysis given above that the amount of solids in broths is generally small. Consequently their strong taste and stimulating effect upon the nervous system must be ascribed to the meat bases (flavoring matters) and to the salts of potash which they contain. Besides meat bases, soups contain more or less gelatin, varying directly with the quantity of bones used in the preparation.

The term meat extract is commonly applied to a large number of preparations of very different character. They may be conveniently divided into three classes: (1) True meat extracts; (2) meat juice obtained by pressure and preserved, compounds which contain dried pulverized meat, and similar preparations; and (3) albumose or peptose preparations, commonly called predigested foods.

The true meat extract, if pure, contains little else besides the flavoring matters of the meat from which it is prepared, together with such mineral salts as may be dissolved out. It should contain no gelatin or fat, and can not, from the way in which it is made, contain any albumen. It is, therefore, not a food at all, but a stimulant, and should be classed with tea, coffee, and other allied substances. It should never be administered to the sick except as directed by competent medical advice. Its strong, meaty taste is deceptive, and the person depending upon it alone for food would certainly die of starvation. Such meat extracts are often found useful in the kitchen for flavoring soups, sauces, etc. Broth and beef tea as prepared ordinarily in the household contain more or less protein, gelatin, and fat, and therefore are foods as well as stimulants. The proportion of water in such compounds is always very large.

The preserved meat juice and similar preparations contain more or less protein, and therefore have some value as food.

The third class of preparations is comparatively new. The better ones are really what they claim to be—predigested foods. They contain the soluble albumoses (peptoses), etc., which are obtained from meat by artificial digestion. Their use should be regulated by competent medical advice.

### ROASTING.

The principal difference between roasting and boiling is in the medium in which the meat is cooked. In boiling, the flesh to be cooked is surrounded by boiling water; in roasting, by hot air, although in roasting proper much of the heat comes to the joint as "radiant" heat. In both cases, if properly conducted, the fibers of the meats are cooked in their own juices.

When the meat alone is to be eaten, either roasting, broiling, or frying in deep fat is, when properly done, a more rational method than boiling, for the juices are very largely saved. The shrinkage in a roast of meat during cooking is chiefly due to a loss of water. At the same time small amounts of carbon and nitrogen are driven off and a little acid is produced which dissolves some of the constituents of the meat. The fat undergoes a partial decomposition into fatty acids and glycerin, and a little of it is volatilized.

It is interesting and at the same time important to remember that the smaller the cut to be roasted the hotter should be the fire. An intensely hot fire coagulates the exterior and prevents the drying up of the meat juices. This method would not, however, be applicable to large cuts, because meats are poor conductors of heat, and a large piece of meat exposed to this intense heat would become burned and changed to charcoal on the exterior long before the heat could penetrate to the interior. Hence the rule: The smaller the çut to be roasted, the higher the temperature to which it should be exposed.

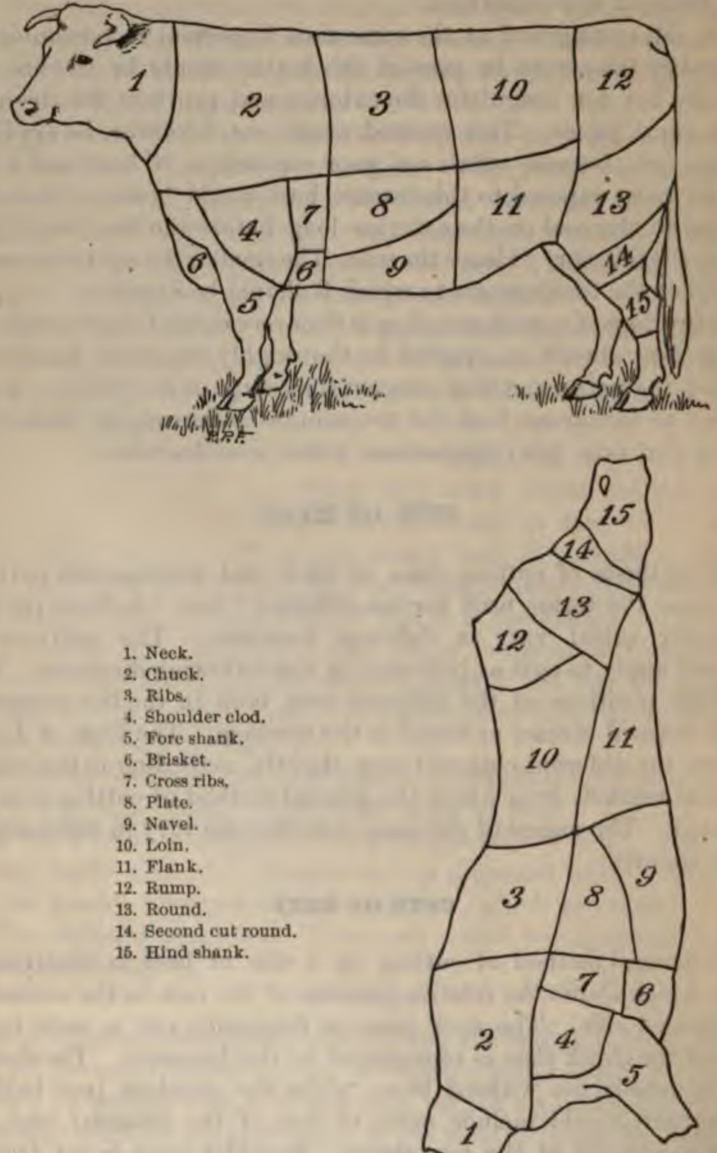
The broiling of a steak or a chop is done on exactly this principle. An intense heat should be applied to thoroughly coagulate the albumen and stop the pores, and thus prevent the escape of the juices. A steak exposed to an intense heat for ten minutes is thoroughly cooked, and has yet that rare, juicy appearance which is so desirable.

## CUTS OF MEAT.

The methods of cutting sides of beef, veal, mutton, and pork into parts, and the terms used for the different "cuts," as these parts are commonly called, vary in different localities. The analyses here reported apply to cuts as indicated by the following diagrams. These show the positions of the different cuts, both in the live animal and in the dressed carcass as found in the markets. The lines of division between the different cuts will vary slightly, according to the usage of the local market, even where the general method of cutting is as here indicated. The names of the same cuts likewise vary in different parts of the country.

### CUTS OF BEEF.

The general method of cutting up a side of beef is illustrated in fig. 1, which shows the relative position of the cuts in the animal and in a dressed side. The neck piece is frequently cut so as to include more of the chuck than is represented by the diagrams. The shoulder clod is usually cut without bone, while the shoulder (not indicated in diagram) would include more or less of the shoulder blade and of the upper end of the fore shank. Shoulder steak is cut from the chuck. In many localities the plate is made to include all the parts of the forequarter designated on the diagrams as brisket, cross-ribs, plate and navel, and different portions of the plate, as thus cut, are spoken of as the "brisket end of plate" and "navel end of plate." This part of the animal is largely used for corning. The ribs are frequently divided into first, second, and third cuts, the latter lyi nearest the chuck and being slightly less desirable than the form The chuck is sometimes subdivided in a similar manner the third c



1. Neck.
2. Chuck.
3. Ribs.
4. Shoulder clod.
5. Fore shank.
6. Brisket.
7. Cross ribs.
8. Plate.
9. Navel.
10. Loin.
11. Flank.
12. Rump.
13. Round.
14. Second cut round.
15. Hind shank.

FIG. 1.—Diagrams of cuts of beef.

of the chuck being nearest the neck. The names applied to differe portions of the loin vary considerably in different localities. The pa nearest the ribs is freqently called "small end of loin" or "sho ak." The other end of the loin is called "hip sirloin" or "sirloin." tween the short and the sirloin is a portion quite generally called "tenderloin," for the reason that the real tenderloin, the very tender ip of meat lying inside the loin, is found most fully developed in this Porterhouse steak is a term most frequently applied to either the rt steak or the tenderloin. It is not uncommon to find the flank so as to include more of the loin than is indicated in the figures, in ich case the upper portion is called "flank steak." The larger part the flank is, however, very frequently corned, as is also the case with rump. In some markets the rump is cut so as to include a portion the loin, which is then sold as "rump steak." The portion of the and on the inside of the leg is regarded as more tender than that the outside, and is frequently preferred to the latter. As the leg s upon the butcher's table this inside of the round is usually on the per, or top side, and is therefore called "top round." Occasionally e plate is called the "rattle."

### CUTS OF VEAL.

The method of cutting up a side of veal differs considerably from t employed with beef. This is illustrated by fig. 2, which shows relative position of the cuts in the animal and in a dressed side.

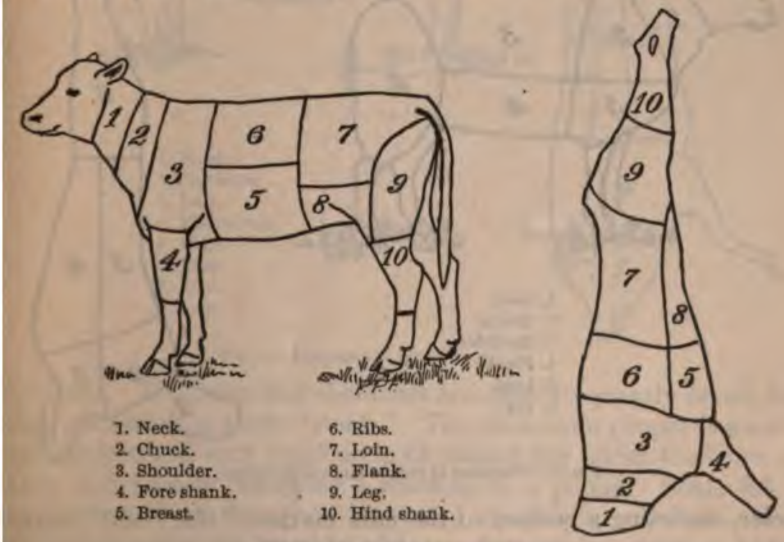


FIG. 2.—Diagrams of cuts of veal.

chuck is much smaller in proportion, and frequently no distinction nade between the chuck and the neck. The chuck is often cut so o include a considerable of the portion here designated as shoulder, owing more nearly the method adopted for subdividing beef. The shoulder of veal as here indicated includes, besides the portion corresponding to the shoulder in beef, the larger part of what is here classed as chuck in the adult animal. The under part of the forequarter, corresponding to the plate in the beef, is often designated as breast in the veal. The part of the veal corresponding to the rump of beef is here included with the loin, but is often cut to form part of the leg. In many localities the fore and hind shanks of veal are called the "knuckles."

### CUTS OF LAMB AND MUTTON.

Fig. 3 shows the relative position of the cuts in a dressed side of mutton or lamb and in a live animal. The cuts in a side of lamb and mutton number but six, three in each quarter. The chuck includes the ribs as far as the end of the shoulder blades, beyond which comes the loin. The flank is made to include all the under side of the animal. Some butchers, however, make a larger number of cuts in the forequarter, including a portion of the cuts marked "loin" and "chuck" in fig. 3, to make a cut designated as "rib," and a portion of the "flank" and "shoulder" to make a cut designated as "brisket." The term "chops" is ordinarily used to designate portions of either the loin, ribs, chuck or shoulder, which are either cut or "chopped" by the butcher into pieces suitable for frying or broiling. The chuck and ribs are sometimes called the "rack."

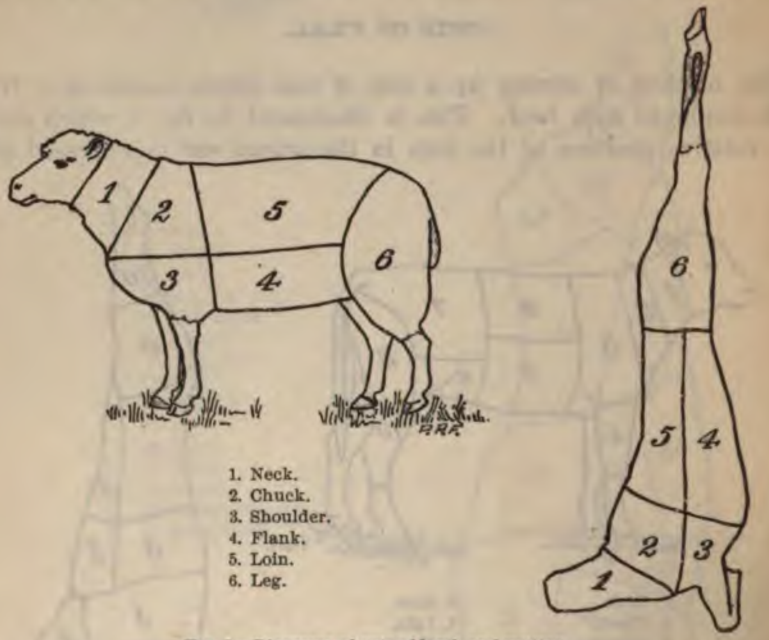


FIG. 3.—Diagrams of cuts of lamb and mutton.

## CUTS OF PORK.

The method of cutting up a side of pork differs considerably from ıt employed with other meats. A large portion of the carcass of a essed pig consists of almost clear fat. This furnishes the cuts which used for "salt pork" and bacon. Fig. 4 illustrates a common thod of cutting up pork, showing the relative position of the cuts the animal and in the dressed side. The cut designated as "back" is almost clear fat and is used for salting and pickling. The niddle cut" is the portion quite generally used for bacon and for ean ends" salt pork. The belly is salted or pickled or may be made o sausages.

Beneath the "back cut" are the ribs and loin, from which are tained "spareribs," "chops," and roasting pieces, here designated by

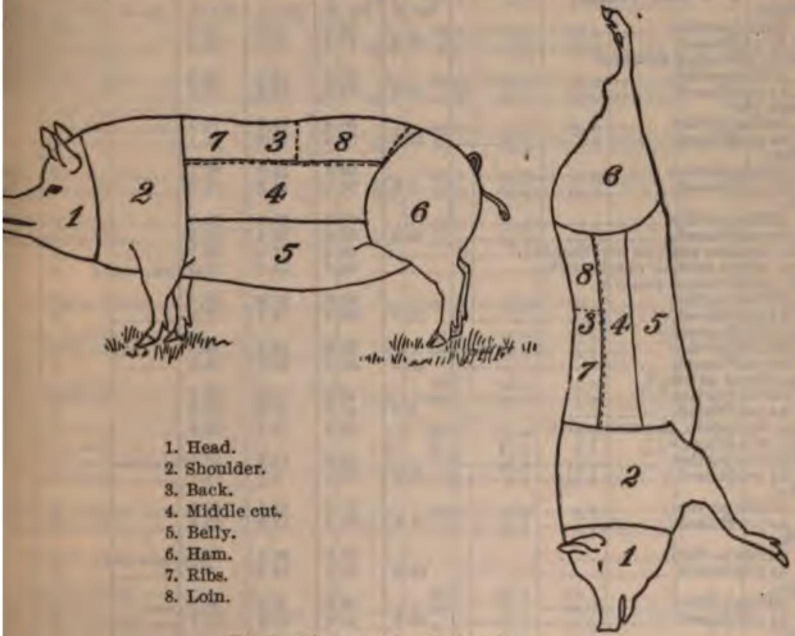


FIG. 4.—Diagrams of cuts of pork.

ed lines. The hams and shoulders are more frequently cured, but also sold fresh as pork "steak." The tenderloin proper is a comtively lean and very small strip of meat lying under the bones of loin and usually weighing a fraction of a pound. Some fat is ally trimmed off from the hams and shoulders, which is called m and shoulder fat," and is often used for sausages, etc. What alled "leaf lard," at least in some localities, comes from the inside he back. It is the kidney fat.

s stated above, cuts as shown in the diagrams herewith correspond hose of which analyses are reported in the table beyond, but do attempt to show the different methods of cutting followed in kets in different parts of the United States.

## COMPOSITION AND FUEL VALUE OF MEATS.

Within recent years analyses of a large number of samples o
have been made in this country. In the table below, the average
of these analyses are given. Analyses of fish are not inc
because the subject of the composition and nutritive value of
fully treated in another bulletin of this series.[a]

*Average chemical composition of different kinds of meat.*

| Food materials. | Refuse. | Water. | Protein (N × 6.25). | Fat. | Total carbo-hy-drates. | Ash. |
|---|---|---|---|---|---|---|
| BEEF, FRESH. | | | | | | |
| Brisket: | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct* |
| Edible portion | ........ | 54.6 | 15.8 | 28.5 | ........ | 0. |
| As purchased | 23.3 | 41.6 | 12.0 | 22.3 | ........ | . |
| Chuck, including shoulder: | | | | | | |
| Edible portion | ........ | 65.0 | 19.2 | 15.4 | ........ | . |
| As purchased | 17.3 | 54.0 | 15.8 | 12.5 | ........ | . |
| Chuck rib: | | | | | | |
| Edible portion | ........ | 66.8 | 19.0 | 13.4 | ........ | 1. |
| As purchased | 19.1 | 53.8 | 15.3 | 11.1 | ........ | . |
| Flank: | | | | | | |
| Edible portion | ........ | 59.3 | 19.6 | 21.1 | ........ | . |
| As purchased | 5.5 | 56.1 | 18.6 | 19.9 | ........ | . |
| Loin: | | | | | | |
| Edible portion | ........ | 61.3 | 19.0 | 19.1 | ........ | 1. |
| As purchased | 13.3 | 52.9 | 16.4 | 16.9 | ........ | . |
| Loin, boneless strip, as purchased[b] | ........ | 66.3 | 17.8 | 16.7 | ........ | . |
| Loin, sirloin butt, as purchased[b] | ........ | 62.5 | 19.7 | 17.7 | ........ | . |
| Loin, porter house steak:[b] | | | | | | |
| Edible portion | ........ | 60.0 | 21.9 | 20.4 | ........ | 1. |
| As purchased | 12.7 | 52.4 | 19.1 | 17.9 | ........ | . |
| Loin, sirloin steak:[b] | | | | | | |
| Edible portion | ........ | 61.9 | 18.9 | 18.5 | ........ | 1. |
| As purchased | 12.8 | 54.0 | 16.5 | 16.1 | ........ | . |
| Loin, top of sirloin:[b] | | | | | | |
| Edible portion | ........ | 42.2 | 13.8 | 43.7 | ........ | 0. |
| As purchased | 3.2 | 40.9 | 13.3 | 42.3 | ........ | . |
| Loin, tenderloin, as purchased:[b] | ........ | 59.2 | 16.2 | 24.4 | ........ | . |
| Loin, trimmings:[b] | | | | | | |
| Edible portion | ........ | 55.0 | 16.9 | 28.0 | ........ | . |
| As purchased | 48.8 | 27.9 | 8.5 | 14.7 | ........ | . |
| Navel: | | | | | | |
| Edible portion | ........ | 47.6 | 15.6 | 36.5 | ........ | . |
| As purchased | 11.4 | 42.2 | 13.8 | 32.3 | ........ | . |
| Neck: | | | | | | |
| Edible portion | ........ | 66.3 | 20.7 | 12.7 | ........ | 1. |
| As purchased | 31.2 | 45.3 | 14.2 | 9.2 | ........ | . |
| Plate: | | | | | | |
| Edible portion | ........ | 56.3 | 16.8 | 26.9 | ........ | . |
| As purchased | 19.8 | 44.4 | 13.1 | 22.7 | ........ | . |
| Ribs: | | | | | | |
| Edible portion | ........ | 57.0 | 17.8 | 24.6 | ........ | . |
| As purchased | 20.1 | 45.3 | 14.4 | 20.0 | ........ | . |
| Rib rolls, as purchased | ........ | 64.8 | 19.4 | 15.5 | ........ | . |
| Rib trimmings: | | | | | | |
| Edible portion | ........ | 54.7 | 16.9 | 28.4 | ........ | . |
| As purchased | 34.1 | 35.7 | 11.0 | 19.2 | ........ | . |
| Ribs, cross: | | | | | | |
| Edible portion | ........ | 54.9 | 15.9 | 28.2 | ........ | . |
| As purchased | 12.5 | 48.0 | 13.8 | 24.8 | ........ | . |
| Round: | | | | | | |
| Edible portion | ........ | 67.8 | 20.9 | 10.6 | ........ | 1. |
| As purchased | 8.5 | 62.5 | 19.2 | 9.2 | ........ | 1. |
| Round, second cut: | | | | | | |
| Edible portion | ........ | 69.8 | 20.4 | 8.6 | ........ | 1. |
| As purchased | 19.5 | 56.2 | 16.4 | 6.9 | ........ | . |
| Rump: | | | | | | |
| Edible portion | ........ | 57.9 | 18.7 | 23.1 | ........ | . |
| As purchased | 19.0 | 46.9 | 15.2 | 18.6 | ........ | . |
| Shank, fore: | | | | | | |
| Edible portion | ........ | 70.8 | 21.4 | 8.1 | ........ | . |
| As purchased | 38.3 | 43.2 | 13.2 | 5.2 | ........ | . |

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[a] U. S. Dept. Agr., Farmers' Bul. 85.

[b] All loin parts are included under analyses of "

*Average chemical composition of different kinds of meat*—Continued.

| Food materials. | Refuse. | Water. | Protein (N × 6.25). | Fat. | Total carbo-hy-drates. | Ash. | Fuel value per pound. |
|---|---|---|---|---|---|---|---|
| BEEF, FRESH—continued. | | | | | | | |
| nd: | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Cals.* |
| portion | ........ | 69.6 | 21.7 | 8.7 | ........ | 1.0 | 776 |
| chased | 55.4 | 31.0 | 9.7 | 3.9 | ........ | .4 | 345 |
| nd clod: | | | | | | | |
| portion | ........ | 68.9 | 20.0 | 10.3 | ........ | 1.1 | 805 |
| chased | 17.4 | 57.0 | 16.5 | 8.4 | ........ | .9 | 660 |
| portion | ........ | 57.1 | 16.9 | 25.2 | ........ | 1.0 | 1,380 |
| chased | 35.8 | 36.7 | 10.8 | 16.2 | ........ | .6 | 885 |
| er, lean: | | | | | | | |
| portion | ........ | 68.6 | 18.9 | 12.2 | ........ | .8 | 865 |
| chased | 22.3 | 53.3 | 14.7 | 9.5 | ........ | .6 | 675 |
| er, medium fat: | | | | | | | |
| portion | ........ | 60.4 | 17.9 | 21.4 | ........ | .9 | 1,235 |
| chased | 18.7 | 49.1 | 14.5 | 17.5 | ........ | .7 | 1,010 |
| er: | | | | | | | |
| portion | ........ | 62.5 | 18.3 | 18.9 | ........ | .9 | 1,135 |
| chased | 20.6 | 49.5 | 14.4 | 15.1 | ........ | .7 | 905 |
| ter, lean: | | | | | | | |
| portion | ........ | 66.3 | 20.0 | 13.4 | ........ | 1.0 | 935 |
| chased | 16.6 | 55.3 | 16.7 | 11.2 | ........ | .8 | 785 |
| ter, medium fat: | | | | | | | |
| portion | ........ | 59.8 | 18.3 | 21.6 | ........ | .9 | 1,250 |
| chased | 15.7 | 50.4 | 15.4 | 18.3 | ........ | .7 | 1,060 |
| ter: | | | | | | | |
| portion | ........ | 62.2 | 19.3 | 18.3 | ........ | .9 | 1,130 |
| chased | 16.3 | 52.0 | 16.1 | 15.4 | ........ | .8 | 950 |
| portion | ........ | 62.2 | 18.8 | 18.8 | ........ | .9 | 1,145 |
| chased | 18.6 | 50.5 | 15.2 | 15.5 | ........ | .7 | 935 |
| BEEF ORGANS. | | | | | | | |
| ble portion | ........ | 80.6 | 8.8 | 9.3 | ........ | 1.1 | 555 |
| portion | ........ | 62.6 | 16.0 | 20.4 | ........ | 1.0 | 1,160 |
| chased | 5.9 | 53.2 | 14.8 | 24.7 | ........ | .9 | 1,320 |
| portion | ........ | 76.7 | 16.6 | 4.8 | 0.4 | 1.2 | 520 |
| chased | 19.9 | 63.1 | 13.7 | 1.9 | ........ | 1.0 | 335 |
| portion | ........ | 71.2 | 20.4 | 4.5 | 1.7 | 1.6 | 605 |
| chased | 7.3 | 65.6 | 20.2 | 3.1 | 2.5 | 1.3 | 555 |
| ds, as purchased | ........ | 70.9 | 16.8 | 12.1 | ........ | 1.6 | 825 |
| rchased | ........ | 13.7 | 4.7 | 81.8 | ........ | .3 | 3,540 |
| portion | ........ | 70.8 | 18.9 | 9.2 | ........ | 1.0 | 740 |
| chased | 26.5 | 51.8 | 14.1 | 6.7 | ........ | .8 | 545 |
| BEEF, COOKED. | | | | | | | |
| purchased | ........ | 23.2 | 21.4 | 51.7 | ........ | 3.5 | 2,580 |
| urchased | ........ | 48.2 | 22.3 | 28.6 | ........ | 1.3 | 1,620 |
| purchased | ........ | 44.1 | 23.6 | 27.7 | ........ | 1.5 | 1,610 |
| ak, fat removed, as purchased | ........ | 63.0 | 27.6 | 7.7 | ........ | 1.8 | 840 |
| , tenderloin, broiled, edible portion | ........ | 54.8 | 23.5 | 20.4 | ........ | 1.2 | 1,300 |
| meat, as purchased | ........ | 58.3 | 28.0 | 11.0 | ........ | 2.8 | 985 |
| BEEF, CANNED. | | | | | | | |
| f, as purchased | ........ | 51.8 | 25.5 | 22.5 | ........ | 1.3 | 1,425 |
| arne, as purchased | ........ | 75.4 | 13.3 | 4.6 | 4.0 | 2.7 | 515 |
| inced, as purchased | ........ | 72.3 | 17.8 | 6.8 | 1.1 | 1.9 | 640 |
| ef | ........ | 51.8 | 26.3 | 18.7 | ........ | 4.0 | 1,280 |
| , as purchased | ........ | 44.8 | 39.2 | 5.4 | ........ | 11.2 | 960 |
| tewed, as purchased | ........ | 71.9 | 18.4 | 5.1 | 2.1 | 2.5 | 600 |
| beef, as purchased | ........ | 52.9 | 27.6 | 15.9 | ........ | 4.8 | 1,185 |
| as purchased | ........ | 66.1 | 22.2 | 8.4 | ........ | 3.2 | 765 |
| , as purchased | ........ | 71.4 | 17.8 | 10.0 | ........ | 1.2 | 755 |
| portion | ........ | 67.9 | 26.3 | 6.3 | ........ | 1.2 | 755 |
| chased | 29.7 | 47.7 | 18.5 | 4.5 | ........ | .8 | 535 |
| , as purchased | ........ | 58.9 | 25.9 | 14.8 | ........ | 1.3 | 1,105 |
| ound, as purchased | ........ | 49.9 | 21.4 | 25.1 | ........ | 4.0 | 1,455 |
| hole, as purchased | ........ | 51.3 | 19.5 | 23.2 | ........ | 4.0 | 1,340 |
| urchased | ........ | 74.6 | 16.8 | 8.5 | ........ | .5 | 670 |

*Average chemical composition of different kinds of meat*—Continued.

| Food materials. | Refuse. | Water. | Protein (N × 6.25). | Fat. | Total carbohydrates. | Ash. |
|---|---|---|---|---|---|---|
| BEEF, CORNED AND PICKLED. | | | | | | |
| Brisket: | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per c* |
| Edible portion | ........ | 50.9 | 18.3 | 24.7 | ........ | 5. |
| As purchased | 21.4 | 40.0 | 14.4 | 19.4 | ........ | 4. |
| Flank: | | | | | | |
| Edible portion | ........ | 49.9 | 14.6 | 33.0 | ........ | 2. |
| As purchased | 12.1 | 43.7 | 12.9 | 29.2 | ........ | 2. |
| Plate: | | | | | | |
| Edible portion | ........ | 40.1 | 13.7 | 41.9 | ........ | 4. |
| As purchased | 14.5 | 34.3 | 11.7 | 35.8 | ........ | 4. |
| Rump: | | | | | | |
| Edible portion | ........ | 58.1 | 15.3 | 23.3 | ........ | 3. |
| As purchased | 6.0 | 54.5 | 14.3 | 22.0 | ........ | 3. |
| Extra family beef: | | | | | | |
| Edible portion | ........ | 37.0 | 12.3 | 47.2 | ........ | 4. |
| As purchased | 10.4 | 33.1 | 11.1 | 42.3 | ........ | 2. |
| Mess beef, salted: | | | | | | |
| Edible portion | ........ | 37.0 | 12.6 | 44.5 | ........ | 6. |
| As purchased | 10.5 | 33.0 | 11.2 | 39.9 | ........ | 5. |
| Corned beef: | | | | | | |
| Edible portion | ........ | 53.6 | 15.6 | 26.2 | ........ | 4. |
| As purchased | 8.4 | 49.2 | 14.3 | 23.8 | ........ | 4. |
| Spiced beef, rolled, as purchased | ........ | 30.0 | 12.0 | 51.4 | ........ | 6. |
| Tongues, pickled: | | | | | | |
| Edible portion | ........ | 62.3 | 12.8 | 20.5 | ........ | 4. |
| As purchased | 6.0 | 58.9 | 11.9 | 19.2 | ........ | 4. |
| Tripe, as purchased | ........ | 86.5 | 11.7 | 1.2 | 0.2 | . |
| Dried, salted, and smoked: | | | | | | |
| Edible portion | ........ | 54.3 | 30.0 | 6.5 | .4 | 9. |
| As purchased | 4.7 | 58.7 | 26.4 | 6.9 | ........ | 8. |
| VEAL, FRESH. | | | | | | |
| Breast, very lean: | | | | | | |
| Edible portion | ........ | 73.2 | 23.1 | 2.5 | ........ | 1. |
| As purchased | 46.8 | 38.9 | 12.3 | 1.3 | ........ | . |
| Breast: | | | | | | |
| Edible portion | ........ | 68.2 | 20.3 | 11.0 | ........ | 1. |
| As purchased | 24.5 | 51.3 | 15.3 | 8.6 | ........ | . |
| Chuck: | | | | | | |
| Edible portion | ........ | 73.8 | 19.7 | 5.8 | ........ | 1. |
| As purchased | 19.0 | 59.8 | 16.0 | 4.7 | ........ | . |
| Flank, as purchased | ........ | 66.9 | 20.1 | 12.7 | ........ | 1. |
| Leg: | | | | | | |
| Edible portion | ........ | 71.7 | 20.7 | 6.7 | ........ | 1. |
| As purchased | 11.7 | 63.4 | 18.3 | 5.8 | ........ | 1. |
| Leg, cutlets: | | | | | | |
| Edible portion | ........ | 70.7 | 20.3 | 7.7 | ........ | 1. |
| As purchased | 3.4 | 68.3 | 20.1 | 7.5 | ........ | 1. |
| Loin: | | | | | | |
| Edible portion | ........ | 69.5 | 19.9 | 10.0 | ........ | 1. |
| As purchased | 18.9 | 56.3 | 16.1 | 8.2 | ........ | . |
| Neck: | | | | | | |
| Edible portion | ........ | 72.6 | 20.3 | 6.9 | ........ | 1. |
| As purchased | 31.5 | 49.9 | 13.9 | 4.6 | ........ | . |
| Rib: | | | | | | |
| Edible portion | ........ | 69.8 | 20.2 | 9.4 | ........ | 1. |
| As purchased | 25.0 | 52.3 | 15.2 | 7.1 | ........ | . |
| Rump: | | | | | | |
| Edible portion | ........ | 62.6 | 19.8 | 16.2 | ........ | 1. |
| As purchased | 30.2 | 43.7 | 13.8 | 11.3 | ........ | . |
| Shank, hind: | | | | | | |
| Edible portion | ........ | 78.6 | 20.7 | 5.5 | ........ | 1. |
| As purchased | 61.1 | 28.6 | 8.0 | 2.2 | ........ | . |
| Shoulder, lean: | | | | | | |
| Edible portion | ........ | 73.4 | 20.7 | 4.6 | ........ | 1. |
| As purchased | 18.3 | 59.9 | 16.9 | 3.9 | ........ | 1. |
| Shoulder and flank, medium fat: | | | | | | |
| Edible portion | ........ | 65.2 | 19.7 | 14.4 | ........ | 1. |
| As purchased | 23.0 | 50.2 | 15.1 | 11.0 | ........ | . |
| Forequarter: | | | | | | |
| Edible portion | ........ | 71.7 | 20.0 | 8.0 | ........ | . |
| As purchased | 24.5 | 54.2 | 15.1 | 6.0 | ........ | . |
| Hind quarter: | | | | | | |
| Edible portion | ........ | 70.9 | 20.7 | 8.3 | ........ | 1. |
| As purchased | 20.7 | 56.2 | 16.2 | 6.6 | ........ | . |
| Side, with kidney, fat, and tallow: | | | | | | |
| Edible portion | ........ | 71.3 | 20.2 | 8.1 | ........ | 1. |
| As purchased | 22.6 | 55.2 | 15.6 | 6.3 | ........ | . |

*Average chemical composition of different kinds of meat*—Continued.

| Food materials. | Refuse. | Water. | Protein (N × 6.25). | Fat. | Total carbo-hydrates. | Ash. | Fuel value per pound. |
|---|---|---|---|---|---|---|---|
| VEAL, FRESH—continued. | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Cals.* |
| Heart, as purchased | ........ | 73.2 | 16.8 | 9.6 | ........ | 1.0 | 720 |
| Kidneys, as purchased | ........ | 75.8 | 16.9 | 6.4 | ........ | 1.3 | 585 |
| Liver, as purchased | ........ | 73.0 | 19.0 | 5.3 | ........ | 1.3 | 575 |
| Lungs, as purchased | ........ | 76.8 | 17.1 | 5.0 | ........ | 1.1 | 580 |
| LAMB, FRESH. | | | | | | | |
| Breast or chuck: | | | | | | | |
| Edible portion | ........ | 56.2 | 19.1 | 23.6 | ........ | 1.0 | 1,350 |
| As purchased | 19.1 | 45.5 | 15.4 | 19.1 | ........ | .8 | 1,090 |
| Leg, hind: | | | | | | | |
| Edible portion | ........ | 58.6 | 18.6 | 22.6 | ........ | 1.0 | 1,300 |
| As purchased | 13.8 | 50.3 | 16.0 | 19.7 | ........ | .9 | 1,130 |
| Loin, without kidney and tallow: | | | | | | | |
| Edible portion | ........ | 53.1 | 18.7 | 28.3 | ........ | 1.0 | 1,540 |
| As purchased | 14.8 | 45.3 | 16.0 | 24.1 | ........ | .8 | 1,315 |
| Neck: | | | | | | | |
| Edible portion | ........ | 56.7 | 17.7 | 24.8 | ........ | 1.0 | 1,375 |
| As purchased | 17.7 | 46.7 | 14.6 | 20.4 | ........ | .8 | 1,135 |
| Shoulder: | | | | | | | |
| Edible portion | ........ | 51.8 | 18.1 | 29.7 | ........ | 1.0 | 1,590 |
| As purchased | 20.3 | 41.3 | 14.4 | 23.6 | ........ | .8 | 1,265 |
| Forequarter: | | | | | | | |
| Edible portion | ........ | 55.1 | 18.3 | 25.8 | ........ | 1.0 | 1,430 |
| As purchased | 18.8 | 44.7 | 14.9 | 21.0 | ........ | .8 | 1,165 |
| Hind quarter: | | | | | | | |
| Edible portion | ........ | 60.9 | 19.6 | 19.1 | ........ | 1.0 | 1,170 |
| As purchased | 15.7 | 51.3 | 16.5 | 16.1 | ........ | .9 | 985 |
| Side, without tallow: | | | | | | | |
| Edible portion | ........ | 58.2 | 17.6 | 23.1 | ........ | 1.1 | 1,300 |
| As purchased | 19.3 | 47.0 | 14.1 | 18.7 | ........ | .8 | 1,055 |
| LAMB, COOKED. | | | | | | | |
| Chops, broiled: | | | | | | | |
| Edible portion | ........ | 47.6 | 21.7 | 29.9 | ........ | 1.3 | 1,665 |
| As purchased | 13.5 | 40.1 | 18.4 | 26.7 | ........ | 1.2 | 1,470 |
| Leg, roast | ........ | 67.1 | 19.7 | 12.7 | ........ | .8 | 900 |
| Tongue, spiced and cooked: | | | | | | | |
| Edible portion | ........ | 67.4 | 13.9 | 17.8 | ........ | .5 | 1,010 |
| As purchased | 2.6 | 65.7 | 13.5 | 17.3 | ........ | .5 | 980 |
| MUTTON, FRESH. | | | | | | | |
| Chuck, lean: | | | | | | | |
| Edible portion | ........ | 64.7 | 17.8 | 16.3 | ........ | .9 | 1,020 |
| As purchased | 19.5 | 52.1 | 14.3 | 13.1 | ........ | .8 | 820 |
| Chuck: | | | | | | | |
| Edible portion | ........ | 48.2 | 14.6 | 36.8 | ........ | .8 | 1,825 |
| As purchased | 19.4 | 38.5 | 11.7 | 30.0 | ........ | .7 | 1,485 |
| Flank: | | | | | | | |
| Edible portion | ........ | 42.7 | 14.3 | 42.6 | ........ | .7 | 2,065 |
| As purchased | 9.9 | 39.0 | 13.8 | 36.9 | ........ | .6 | 1,815 |
| Leg, hind: | | | | | | | |
| Edible portion | ........ | 63.2 | 18.7 | 17.5 | ........ | 1.0 | 1,085 |
| As purchased | 17.7 | 51.9 | 15.4 | 14.5 | ........ | .8 | 900 |
| Loin, without kidney or tallow: | | | | | | | |
| Edible portion | ........ | 47.8 | 15.5 | 36.2 | ........ | .8 | 1,815 |
| As purchased | 14.8 | 40.4 | 13.1 | 31.5 | ........ | .6 | 1,575 |
| Neck: | | | | | | | |
| Edible portion | ........ | 56.6 | 16.7 | 26.3 | ........ | 1.0 | 1,420 |
| As purchased | 26.4 | 41.5 | 12.2 | 19.6 | ........ | .7 | 1,055 |
| Shoulder: | | | | | | | |
| Edible portion | ........ | 60.2 | 17.5 | 21.8 | ........ | .9 | 1,245 |
| As purchased | 22.1 | 46.8 | 13.7 | 17.1 | ........ | .7 | 975 |
| Forequarter: | | | | | | | |
| Edible portion | ........ | 52.9 | 15.6 | 30.9 | ........ | .9 | 1,595 |
| As purchased | 21.2 | 41.6 | 12.3 | 24.5 | ........ | .7 | 1,265 |
| Hind quarter: | | | | | | | |
| Edible portion | ........ | 54.8 | 16.7 | 28.1 | ........ | .8 | 1,495 |
| As purchased | 17.2 | 45.4 | 13.8 | 23.2 | ........ | .7 | 1,235 |
| Side, including tallow: | | | | | | | |
| Edible portion | ........ | 54.2 | 16.3 | 28.9 | ........ | .9 | 1,520 |
| As purchased | 18.1 | 45.4 | 13.0 | 23.1 | ........ | .7 | 1,215 |
| Side, not including tallow: | | | | | | | |
| Edible portion | ........ | 53.6 | 16.2 | 29.8 | ........ | .8 | 1,560 |
| As purchased | 19.3 | 43.3 | 13.0 | 24.0 | ........ | .7 | 1,255 |
| MUTTON, COOKED. | | | | | | | |
| Mutton, leg roast, edible portion | ........ | 50.9 | 25.0 | 22.6 | ........ | 1.2 | 1,420 |

*Average chemical composition of different kinds of meat*—Continued.

| Food materials. | Refuse. | Water. | Protein (N × 6.25). | Fat. | Total carbohydrates. | Ash. |
|---|---|---|---|---|---|---|
| MUTTON, ORGANS. | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* |
| Heart, as purchased |  | 69.5 | 16.9 | 12.6 |  | .9 |
| Kidneys, as purchased |  | 78.7 | 16.5 | 3.2 |  | 1.3 |
| Liver, as purchased |  | 61.2 | 23.1 | 9.0 | 5.0 | 1.7 |
| MUTTON, CANNED. |  |  |  |  |  |  |
| Corned, as purchased |  | 45.8 | 28.8 | 22.8 |  | 4.2 |
| Tongue, as purchased |  | 47.6 | 24.4 | 24.0 |  | 4.8 |
| PORK, FRESH. |  |  |  |  |  |  |
| Chuck ribs and shoulder: |  |  |  |  |  |  |
| Edible portion |  | 51.1 | 17.3 | 31.1 |  | .9 |
| As purchased | 18.1 | 41.8 | 14.1 | 25.5 |  | .8 |
| Flank: |  |  |  |  |  |  |
| Edible portion |  | 59.0 | 18.5 | 22.2 |  | 1.0 |
| As purchased | 18.0 | 48.5 | 15.1 | 18.6 |  | .7 |
| Ham, fresh: |  |  |  |  |  |  |
| Edible portion |  | 50.1 | 15.7 | 33.4 |  | .9 |
| As purchased | 10.3 | 45.1 | 14.3 | 29.7 |  | .8 |
| Head: |  |  |  |  |  |  |
| Edible portion |  | 45.3 | 13.4 | 41.3 |  | .7 |
| As purchased | 68.4 | 13.8 | 4.1 | 13.8 |  | .2 |
| Head cheese: |  |  |  |  |  |  |
| Edible portion |  | 43.3 | 19.5 | 33.8 |  | 3.3 |
| As purchased | 12.1 | 42.3 | 18.9 | 24.0 |  | 3.0 |
| Loin (chops): |  |  |  |  |  |  |
| Edible portion |  | 50.7 | 16.4 | 32.0 |  | .9 |
| As purchased | 19.3 | 40.8 | 13.2 | 26.0 |  | .8 |
| Loin, tenderloin, as purchased[a] |  | 66.5 | 18.9 | 13.0 |  | 1.0 |
| Middle cuts: |  |  |  |  |  |  |
| Edible portion |  | 48.2 | 15.7 | 36.3 |  | .7 |
| As purchased | 19.7 | 38.6 | 12.7 | 28.9 |  | .7 |
| Shoulder: |  |  |  |  |  |  |
| Edible portion[b] |  | 51.2 | 13.3 | 34.2 |  | .8 |
| As purchased | 12.4 | 44.9 | 12.0 | 29.8 |  | .7 |
| Side, lard and other fat included: |  |  |  |  |  |  |
| Edible portion |  | 29.4 | 9.4 | 61.7 |  | .4 |
| As purchased | 11.2 | 26.1 | 8.3 | 54.8 |  | .4 |
| Side, not including lard and kidney: |  |  |  |  |  |  |
| Edible portion[c] |  | 34.4 | 9.1 | 55.3 |  | .5 |
| As purchased | 11.5 | 30.4 | 8.0 | 49.0 |  | .5 |
| Clear backs: |  |  |  |  |  |  |
| Edible portion[d] |  | 25.1 | 6.4 | 67.6 |  | .4 |
| As purchased | 5.7 | 23.7 | 6.0 | 63.8 |  | .4 |
| Clear bellies: |  |  |  |  |  |  |
| Edible portion[e] |  | 31.4 | 6.9 | 60.4 |  | .4 |
| As purchased | 6.2 | 29.5 | 6.5 | 56.6 |  | .4 |
| Back fat, as purchased |  | 7.7 | 3.6 | 89.9 |  | .1 |
| Belly fat, as purchased |  | 13.8 | 5.2 | 81.9 |  | .2 |
| Ham fat, as purchased |  | 9.1 | 3.5 | 88.0 |  | .2 |
| Jowl fat, as purchased |  | 16.0 | 5.9 | 78.8 |  | .2 |
| Feet: |  |  |  |  |  |  |
| Edible portion[f] |  | 55.4 | 15.8 | 26.3 |  | .8 |
| As purchased | 74.1 | 14.3 | 4.1 | 6.9 |  | .2 |
| Tails: |  |  |  |  |  |  |
| Edible portion[g] |  | 17.4 | 4.8 | 77.1 |  | .3 |
| As purchased | 13.3 | 15.0 | 4.1 | 66.9 |  | .3 |
| Trimmings: |  |  |  |  |  |  |
| Edible portion |  | 23.3 | 5.4 | 70.2 |  | .3 |
| As purchased | 7.4 | 21.6 | 5.0 | 65.0 |  | .3 |
| PORK ORGANS, ETC. |  |  |  |  |  |  |
| Brains, as purchased |  | 75.8 | 11.7 | 10.3 |  | 1.6 |
| Heart, as purchased |  | 75.6 | 17.1 | 6.3 |  | 1.0 |
| Kidneys, as purchased |  | 77.8 | 15.5 | 4.8 |  | 1.2 |
| Liver, as purchased |  | 71.4 | 21.3 | 4.5 | 1.4 | 1.4 |
| Lungs, as purchased |  | 83.3 | 11.9 | 4.0 |  | .9 |
| Marrow, as purchased |  | 14.6 | 2.3 | 81.2 |  |  |
| Skin, as purchased |  | 46.3 | 26.4 | 22.7 |  | .6 |

[a] Eight samples contained an average of lecithin 0.51, gelatinoids 0.6, and "flesh bases" 0.9 per

[b] Eight samples contained an average of lecithin 0.25, gelatinoids 0.8, and "flesh bases" 1.1 per

[c] Eight samples contained an average of lecithin 0.35, gelatinoids 1, and "flesh bases" 1.5 per

[d] Eight samples contained an average of lecithin 0.21, gelatinoids 0.6, and "flesh bases" 0.8 per

[e] Eight samples contained an average of lecithin 0.18, gelatinoids 0.6, and "flesh bases" 0.9 per

[f] Eight samples contained an average of lecithin 0.32, gelatinoids 3.5, and "flesh bases" 2 per

[g] Eight samples contained an average of lecithin 0.20, gelatinoids 0.6, and "flesh bases" 0.6 per

*Average chemical composition of different kinds of meat*—Continued.

| Food materials. | Refuse. | Water. | Protein (N × 6.25). | Fat. | Total carbo-hy-drates. | Ash. | Fuel value per pound. |
|---|---|---|---|---|---|---|---|
| K, PICKLED, SALTED, AND SMOKED. | | | | | | | |
| moked: | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Cals.* |
| ble portion | ........ | 39.8 | 16.5 | 38.8 | ........ | 4.7 | 1,945 |
| purchased | 12.2 | 35.8 | 14.5 | 33.2 | ........ | 4.2 | 1,670 |
| in, as purchased | ........ | 27.2 | 15.4 | 53.7 | ........ | 3.1 | 2,555 |
| moked, boiled, as purchased | ........ | 51.3 | 20.2 | 22.4 | ........ | 6.1 | 1,320 |
| moked, fried, as purchased | ........ | 36.6 | 22.2 | 33.2 | ........ | 5.8 | 1,815 |
| oneless, raw: | | | | | | | |
| ble portion | ........ | 50.1 | 14.9 | 28.5 | ........ | 6.0 | 1,480 |
| purchased | a3.3 | 48.5 | 14.3 | 27.5 | ........ | 5.8 | 1,425 |
| uncheon, cooked: | | | | | | | |
| ble portion | ........ | 49.2 | 22.5 | 21.0 | ........ | 5.8 | 1,305 |
| purchased | a2.1 | 48.1 | 22.1 | 20.6 | ........ | 5.7 | 1,280 |
| er, smoked: | | | | | | | |
| ble portion | ........ | 37.6 | 15.5 | 41.0 | ........ | 6.1 | 2,020 |
| purchased | 18.9 | 30.7 | 12.6 | 33.0 | ........ | 5.0 | 1,625 |
| ngues, pickled: | | | | | | | |
| ble portion | ........ | 58.6 | 17.7 | 19.8 | ........ | 3.6 | 1,165 |
| purchased | 3.2 | 56.8 | 17.1 | 19.1 | ........ | 3.4 | 1,125 |
| et, pickled: | | | | | | | |
| ble portion | ........ | 68.2 | 16.3 | 14.8 | ........ | .9 | 930 |
| purchased | 35.5 | 44.6 | 10.2 | 9.3 | ........ | .6 | 585 |
| ted backs: | | | | | | | |
| ble portion | ........ | 17.3 | 7.7 | 72.7 | ........ | 2.8 | 3,210 |
| purchased | 8.1 | 15.9 | 7.1 | 66.8 | ........ | 2.7 | 2,950 |
| ted bellies: | | | | | | | |
| ble portion | ........ | 17.7 | 8.4 | 72.2 | ........ | 3.4 | 3,200 |
| purchased | 8.2 | 16.2 | 7.7 | 66.2 | ........ | 3.2 | 2,935 |
| rk, clear fat, as purchased | ........ | 7.9 | 1.9 | 86.2 | ........ | 3.9 | 3,670 |
| rk, lean ends: | | | | | | | |
| ble portion | ........ | 19.9 | 8.4 | 67.1 | ........ | 5.7 | 2,985 |
| purchased | 11.2 | 17.6 | 7.4 | 59.6 | ........ | 5.1 | 2,655 |
| smoked: | | | | | | | |
| ble portion | ........ | 20.2 | 10.5 | 64.8 | ........ | 5.1 | 2,930 |
| purchased | 8.7 | 18.4 | 9.5 | 59.4 | ........ | 4.5 | 2,685 |
| ooked, as purchased | ........ | 33.6 | 24.8 | 37.6 | ........ | 2.2 | 2,050 |
| cooked, as purchased | ........ | 33.2 | ........ | 45.4 | ........ | 1.5 | 2,285 |
| PORK, CANNED. | | | | | | | |
| , boars' brains as purchased | ........ | 49.0 | 25.2 | 23.0 | ........ | 4.6 | 1,440 |
| heads, as purchased | ........ | 55.3 | 20.7 | 22.2 | ........ | 3.3 | 1,320 |
| deviled, as purchased | ........ | 44.1 | 19.0 | 34.1 | ........ | 3.3 | 1,790 |
| SAUSAGE.[b] | | | | | | | |
| ible portion | ........ | 17.2 | 26.8 | 50.6 | ........ | 7.3 | 2,635 |
| purchased | 5.2 | 16.3 | 25.4 | 48.0 | ........ | 6.9 | 2,495 |
| et: | | | | | | | |
| ible portion | ........ | 62.7 | 18.3 | 15.7 | ........ | 3.7 | 1,005 |
| purchased | 1.6 | 61.7 | 18.0 | 15.4 | ........ | 3.6 | 985 |
| na: | | | | | | | |
| ible portion | ........ | 60.0 | 18.7 | 17.6 | 0.3 | 3.7 | 1,095 |
| purchased | 3.3 | 55.2 | 18.2 | 19.7 | ........ | 3.8 | 1,170 |
| r: | | | | | | | |
| ible portion | ........ | 23.2 | 29.0 | 42.0 | ........ | 7.6 | 2,310 |
| purchased | 3.9 | 22.2 | 27.9 | 40.4 | ........ | 7.3 | 2,225 |
| fort, as purchased | ........ | 57.2 | 19.6 | 18.6 | 1.1 | 3.4 | 1,170 |
| ner: | | | | | | | |
| ible portion | ........ | 25.6 | 29.4 | 37.3 | 3.4 | 4.3 | 2,220 |
| purchased | 2.2 | 25.1 | 28.7 | 36.5 | 3.3 | 4.2 | 2,135 |
| pure ham: | | | | | | | |
| ible portion | ........ | 32.5 | 32.3 | 27.2 | ........ | 8.0 | 1,750 |
| purchased | 10.0 | 29.2 | 29.1 | 24.5 | ........ | 7.2 | 1,575 |
| as purchased | ........ | 39.8 | 13.0 | 44.2 | 1.1 | 2.2 | 2,125 |
| ausage meat, as purchased | ........ | 46.2 | 17.4 | 32.5 | ........ | 3.4 | 1,695 |
| and beef chopped together, as pur-ed | ........ | 55.4 | 19.4 | 24.1 | ........ | 1.0 | 1,380 |
| ible portion | ........ | 30.5 | 24.1 | 39.9 | ........ | 7.0 | 2,130 |
| purchased | 9.3 | 27.6 | 21.8 | 36.2 | ........ | 6.4 | 1,935 |

fuse, case.

some cases the sum of the percentages of water, protein, fat, and ash in sausage does not make n such cases the difference is estimated as carbohydrates. There are, however, no tests show-e presence of these, and it may be more nearly correct to give no value for carbohydrates.

*Average chemical composition of different kinds of meat*—Continued.

| Food materials. | Refuse. | Water. | Protein (N × 6.25). | Fat. | Total carbo-hydrates. | Ash. |
|---|---|---|---|---|---|---|
| SAUSAGE—continued. | | | | | | |
| Summer: | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* |
| Edible portion | ........ | 23.2 | 26.0 | 44.5 | ........ | 7.7 |
| As purchased | 7.0 | 20.9 | 24.5 | 42.1 | ........ | 7.0 |
| Tongue, as purchased | ........ | 46.4 | 20.1 | 33.1 | ........ | 3.2 |
| Wienerwurst, as purchased | ........ | 43.9 | 28.0 | 22.1 | 1.6 | 4.4 |
| SAUSAGE, CANNED. | | | | | | |
| Beef, as purchased | ........ | 59.6 | 17.9 | 20.6 | ........ | 2.0 |
| Bologna, Italian, as purchased | ........ | 42.6 | 24.9 | 27.8 | ........ | 4.4 |
| Frankfort, as purchased | ........ | 72.7 | 14.9 | 9.9 | ........ | 2.8 |
| Oxford, as purchased | ........ | 28.9 | 9.9 | 58.5 | 0.6 | 2.1 |
| Pork: | | | | | | |
| Edible portion | ........ | 56.6 | 16.6 | 24.8 | ........ | 2.0 |
| As purchased | [a]12.6 | 49.5 | 14.5 | 21.6 | ........ | 1.8 |
| CHICKENS. | | | | | | |
| Young: | | | | | | |
| As purchased | 18.8 | 55.5 | 17.8 | 7.2 | ........ | .9 |
| Edible portion | ........ | 68.4 | 21.9 | 8.9 | ........ | 1.1 |
| Meat, not including giblets | ........ | 66.9 | 22.6 | 10.1 | ........ | 1.1 |
| Dark meat | ........ | 70.1 | 20.8 | 8.2 | ........ | 1.2 |
| Light meat | ........ | 70.3 | 21.9 | 7.4 | ........ | 1.1 |
| Giblets | ........ | 71.0 | 19.8 | 6.4 | ........ | 1.3 |
| Liver | ........ | 69.3 | 22.4 | 4.2 | 2.4 | 1.7 |
| Heart | ........ | 72.0 | 20.7 | 5.5 | ........ | 1.6 |
| Gizzard | ........ | 72.5 | 24.7 | 1.4 | ........ | 1.4 |
| Broiler: | | | | | | |
| As purchased | 29.1 | 51.2 | 15.5 | 3.3 | ........ | .8 |
| Edible portion | ........ | 69.7 | 20.7 | 8.3 | ........ | 1.1 |
| Meat, not including giblets | ........ | 69.2 | 21.1 | 8.8 | ........ | 1.1 |
| Giblets | ........ | 72.8 | 18.7 | 6.1 | ........ | 1.3 |
| Capon: | | | | | | |
| As purchased | 17.5 | 46.8 | 17.7 | 17.5 | ........ | 1.0 |
| Edible portion | ........ | 56.7 | 21.5 | 21.2 | ........ | 1.2 |
| Meat, not including giblets | ........ | 55.8 | 21.6 | 22.1 | ........ | 1.2 |
| Giblets | ........ | 63.3 | 20.5 | 14.6 | ........ | 1.3 |
| Other: | | | | | | |
| As purchased | 25.2 | 47.3 | 14.4 | 12.6 | ........ | .7 |
| Edible portion | ........ | 59.5 | 20.4 | 19.2 | ........ | 1.1 |
| Meat, not including giblets | ........ | 63.4 | 19.4 | 16.6 | ........ | 1.0 |
| Giblets | ........ | 64.7 | 18.7 | 13.7 | ........ | 1.3 |
| OTHER FOWL. | | | | | | |
| Turkey: | | | | | | |
| As purchased | 14.3 | 49.2 | 19.0 | 16.2 | ........ | 1.0 |
| Edible portion | ........ | 57.4 | 22.2 | 18.9 | ........ | 1.2 |
| Dark meat | ........ | 57.0 | 21.4 | 20.6 | ........ | 1.1 |
| Light meat | ........ | 63.9 | 25.7 | 9.4 | ........ | 1.3 |
| Giblets | ........ | 56.7 | 17.7 | 23.5 | ........ | 1.2 |
| Dark meat, cooked | ........ | 53.7 | 39.2 | 4.3 | ........ | 2.2 |
| Light meat, cooked | ........ | 58.5 | 34.6 | 4.9 | ........ | 1.8 |
| Young, as purchased | 32.4 | 44.7 | 16.8 | 5.9 | ........ | .9 |
| Young, edible portion | ........ | 66.1 | 24.9 | 8.7 | ........ | 1.3 |
| Cooked | ........ | 52.0 | 27.8 | 18.4 | ........ | 1.2 |
| Heart | ........ | 68.6 | 16.8 | 13.2 | ........ | 1.0 |
| Liver | ........ | 69.6 | 22.9 | 5.2 | .6 | 1.7 |
| Gizzard | ........ | 62.7 | 20.5 | 14.5 | 1.2 | 1.1 |
| Duck: | | | | | | |
| As purchased | 15.9 | 51.4 | 15.4 | 16.0 | ........ | 1.1 |
| Edible portion | ........ | 61.1 | 18.3 | 19.0 | ........ | 1.3 |
| Meat, not including breast or giblets | ........ | 55.5 | 17.4 | 26.1 | ........ | 1.0 |
| Breast | ........ | 73.9 | 22.3 | 2.3 | ........ | 1.3 |
| Giblets | ........ | 73.2 | 17.9 | 5.0 | ........ | 1.8 |
| Duckling: | | | | | | |
| As purchased | 16.2 | 43.3 | 12.0 | 28.0 | ........ | .7 |
| Edible portion | ........ | 51.7 | 14.3 | 33.4 | ........ | .9 |
| Meat, not including giblets | ........ | 48.3 | 13.5 | 37.9 | ........ | .7 |
| Giblets | ........ | 70.2 | 18.9 | 8.1 | ........ | 1.6 |
| Green goose: | | | | | | |
| As purchased | 12.2 | 41.9 | 13.6 | 31.6 | ........ | .8 |
| Edible portion | ........ | 48.2 | 15.1 | 36.0 | ........ | .8 |
| Meat, not including giblets | ........ | 46.0 | 15.0 | 38.3 | ........ | .5 |
| Giblets | ........ | 68.7 | 22.3 | 7.3 | ........ | 1.4 |

[a] Refuse liquid.

*ge chemical composition of different kinds of meat*—Continued.

| d materials. | Refuse. | Water. | Protein (N × 6.25). | Fat. | Total carbo-hy-drates. | Ash. | Fuel value per pound. |
|---|---|---|---|---|---|---|---|
| OWL—continued. | | | | | | | |
| | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Cals.* |
| | 11.1 | 48.0 | 14.8 | 25.5 | ........ | 1.0 | 1,475 |
| | ........ | 54.0 | 16.6 | 28.7 | ........ | 1.1 | 1,660 |
| uding giblets | ........ | 51.8 | 16.2 | 31.5 | ........ | 1.0 | 1,755 |
| | ........ | 70.0 | 20.1 | 8.2 | ........ | 1.7 | 910 |
| | ........ | 73.8 | 19.6 | 5.8 | ........ | 1.0 | 750 |
| | ........ | 62.6 | 16.6 | 15.9 | 3.7 | 1.2 | 1,175 |
| | 13.6 | 55.2 | 19.7 | 9.5 | ........ | 1.3 | 915 |
| | ........ | 64.0 | 22.8 | 11.0 | ........ | 1.5 | 1,060 |
| uding giblets | ........ | 63.2 | 22.9 | 12.1 | ........ | 1.4 | 1,100 |
| | ........ | 68.1 | 22.2 | 5.2 | ........ | 2.3 | 845 |
| | 15.6 | 49.0 | 15.7 | 18.6 | ........ | 1.3 | 1,205 |
| | ........ | 58.0 | 18.6 | 22.1 | ........ | 1.5 | 1,430 |
| uding giblets | ........ | 56.6 | 18.5 | 23.8 | ........ | 1.4 | 1,470 |
| | ........ | 69.8 | 19.8 | 7.2 | ........ | 2.0 | 835 |
| | 16.4 | 57.7 | 19.4 | 5.4 | ........ | 1.1 | 730 |
| | ........ | 69.1 | 23.1 | 6.5 | ........ | 1.3 | 870 |
| uding giblets | ........ | 68.9 | 23.4 | 6.5 | ........ | 1.3 | 865 |
| | ........ | 69.9 | 20.8 | 7.1 | ........ | 1.3 | 855 |
| | 12.0 | 61.5 | 21.5 | 4.2 | ........ | 1.0 | 730 |
| | ........ | 69.9 | 24.4 | 4.8 | ........ | 1.1 | 830 |
| uding giblets | ........ | 70.0 | 24.7 | 4.6 | ........ | 1.1 | 815 |
| | ........ | 68.9 | 20.1 | 7.2 | ........ | 1.6 | 880 |
| | 14.1 | 61.1 | 21.5 | 1.9 | ........ | 1.2 | 635 |
| | ........ | 71.1 | 25.0 | 2.3 | ........ | 1.4 | 740 |
| uding giblets | ........ | 70.6 | 25.7 | 2.3 | ........ | 1.4 | 730 |
| | ........ | 74.4 | 21.2 | 2.2 | ........ | 1.3 | 665 |
| | 10.5 | 59.0 | 22.3 | 6.1 | ........ | 1.4 | 835 |
| | ........ | 65.9 | 25.0 | 6.8 | ........ | 1.6 | 935 |
| uding giblets | ........ | 66.3 | 25.4 | 7.0 | ........ | 1.4 | 945 |
| | ........ | 63.0 | 21.8 | 6.2 | ........ | 2.3 | 970 |
| D POULTRY MEAT. | | | | | | | |
| ast (including skin and | ........ | 35.7 | 20.1 | 38.7 | ........ | 5.5 | 2,210 |
| east (skin and outer fat | ........ | 61.3 | 26.1 | 4.4 | ........ | 8.0 | 845 |
| | ........ | 56.0 | 17.2 | 22.0 | ........ | 3.0 | 1,390 |
| | ........ | 56.1 | 19.4 | 20.3 | ........ | 2.5 | 1,390 |
| oup | ........ | 87.1 | 2.9 | 3.3 | 5.1 | 1.6 | 300 |
| umbo soup | ........ | 91.0 | 2.4 | .2 | 4.8 | 1.6 | 160 |
| cken | ........ | 57.6 | 27.7 | 12.8 | ........ | 2.2 | 1,245 |
| chicken | ........ | 46.9 | 20.8 | 30.0 | ........ | 2.6 | 1,825 |
| turkey | ........ | 47.4 | 20.7 | 29.2 | ........ | 2.7 | 1,790 |
| | ........ | 66.9 | 21.8 | 8.0 | 1.7 | 1.6 | 935 |
| as | ........ | 41.3 | 13.6 | 38.2 | 4.3 | 2.6 | 2,075 |

the titles of all Farmers' Bulletins available for distribution will be application to a Member of Congress or the Secretary of Agriculture.]

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 36.

# OTTON SEED AND ITS PRODUCTS.

Prepared in the Office of Experiment Stations.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1896.

# LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
*Washington, D. C., January 30, 189*

SIR: I have the honor to transmit herewith an article on cotton and its products, condensed from original articles by members of office force and others, and to recommend its publication as a Far Bulletin of this Department.

Respectfully,

A. C. TRUE,
*Direct*

Hon. J. STERLING MORTON,
*Secretary of Agriculture.*

# CONTENTS.

# COTTON SEED AND ITS PRODUCTS.

## INTRODUCTION.

The lint was formerly considered the only valuable product of cotton, t modern enterprise has found a use for almost every part of the ant. In fact, of all the staple crops of the United States not one can e produced with a slighter drain upon the elements of fertility of the il than cotton, and none excels it in variety and value of its products.

The lint is comparatively poor in fertilizing constituents, containing ly 0.34 per cent of nitrogen, 0.10 per cent of phosphoric acid, and 46 per cent of potash. It is evident, therefore, that if the lint were e only part of the plant removed from the soil on which it was grown tton would be one of the least exhaustive of farm crops. The only her product of the cotton plant whose fertilizing constituents need be rmanently lost to the soil is the oil, which also contains comparavely insignificant amounts of these constituents. It can be shown hat, even when the seed is taken away along with the lint, cotton still moves smaller amounts of fertilizing materials from the soil than her oats or corn."

If the stubble is turned under (not burned) and the seed or its equivat in meal is returned to the soil, the growing of cotton exhausts the l fertility very slowly. In fact, the direct loss to the soil under these cumstances is not more than one-half pound of phosphoric acid, 1¾ unds of potash, and 1¼ pounds of nitrogen per acre in a crop of 300 unds of lint per acre.

The stalks and other refuse on an acre after the seed cotton has been ked amounts to about 850 pounds in weight with average yields of t. Stock is usually turned in to pasture on this stubble after the last king. The animals strip off the limbs and pods, leaving finally hing but the hard and brittle bare stalks.

ir-dry cotton plants, with seed cotton removed, rank as a feeding ff with the coarse, dry fodders, such as cornshucks, corn stover, and oat, and wheat straw. One hundred pounds of air-dry material tains on the average: Water, 10.01 pounds; ash, 6 13 pounds; pro-, 6.35 pounds; fiber, 34.38 pounds; nitrogen-free extract, 41.15 nds, and fat, 1.98 pounds.

t has been proposed to utilize the cotton stem for the preparation of r for cotton bagging, etc., and a process has been patented for this pose, but the enterprise has not proved successful, owing largely, if not entirely, to the difficulty of devising a machine that will satisfactorily work up the rough, irregular material. It is claimed that under favorable conditions 5 tons of stalks will yield 1 ton of bark, producing about 1,500 pounds of fiber. Bagging made from this fiber is pronounced by dealers to be of first-class quality. The stalks are also highly valued for fuel in countries such as Egypt, where other supplies are scarce, and the bark of the roots (*Gossypii radicis cortex* U. S. P.) contains a principle which has long been used for medicinal purposes, its action being similar to that of ergot.

As a by-product of the cotton crop of 1894 there was produced about 4,500,000 tons of seed. From this seed, after deducting enough for planting, there could have been expressed 135,000,000 gallons of oil, leaving as a residue 1,200,000 tons of meal, a valuable feeding stuff and fertilizer, besides an equal amount of fair coarse fodder in the form of hulls.

The uses of these by-products have now reached large proportions and are constantly being extended. It is entirely possible that ultimately cotton will be grown as much for tne seed as for the fiber.

Accurate information regarding the value and uses of cotton seed and its products is therefore of great importance not only to the consumer but also to the producer. In the following pages the attempt has been made to give in condensed form the principal facts bearing on this subject.

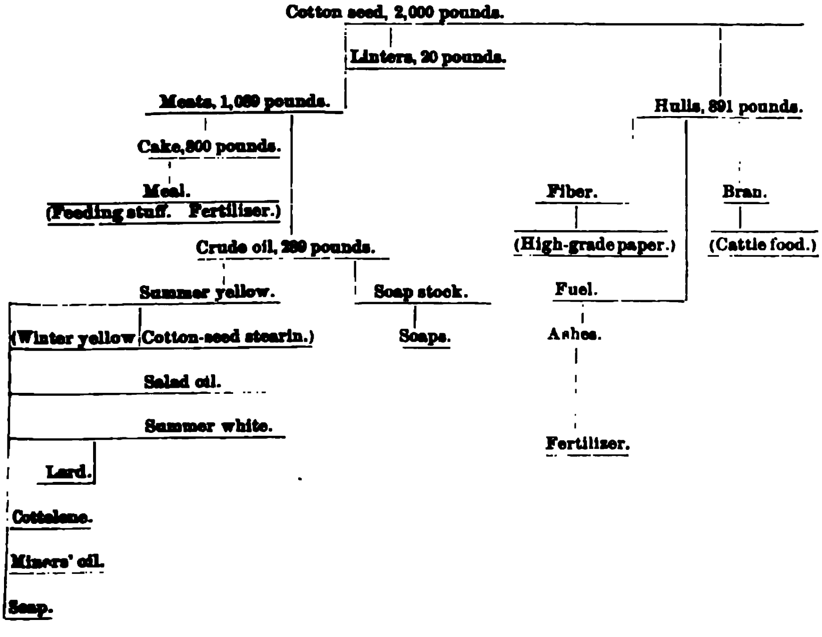
## COTTON SEED.

For many years cotton seed was considered only useful to plant. Thousands of tons of this seed were annually burned or dumped into the rivers. But at last it was shown that cotton seed was not only valuable as a fertilizer and feeding stuff in its crude state, but was capable of furnishing products that are among the most important elements in our national industries. The oil is the main product, and is used for a great variety of purposes, which are explained later (p. 9). The residue after the removal of the oil is a valuable fertilizer and feeding stuff, the hulls excellent fuel, the ashes of the hulls a fertilizer rich in potash and phosphoric acid, and the refuse from the oil refining valuable stock for the manufacture of soaps. The seeds also contain a coloring matter which has been used to some extent as a dyestuff. Thus a vast mass of material which was once looked upon as necessarily a waste product has become of very great commercial value.

As it comes from the gin, upland cotton seed consists of the seed proper and the soft down which adheres closely to the seed hulls. This down, known as "linters" to distinguish it from the longer fibers which constitute the lint of commerce, does not need to be removed from that portion of the seed which is reserved for planting, although delinting, besides yielding a valuable commercial product (linters), makes the seed easier to handle and retards fermentation. Experience has shown that the removal of the linters from the seed prior to decorticating and pressing greatly improves the quality of the oil and other valuable products of the seed. At the oil mills cotton seed, after the removal of the linters, yields practically equal parts of seed coat (or hull) and kernel (or meat). From the latter the oil is expressed, leaving about 800 pounds of cake (or meal) to a ton of seed. The amount of seed worked at the oil mills in the season of 1893–94 is reported at about 1,500,000 tons. This, under favorable conditions, could be made to yield in round numbers 67,000,000 gallons of crude oil, worth, at 25 cents per gallon, $16,750,000; 600,000 tons of meal, worth, at $20 per ton, $12,000,000; 660,000 tons of hulls, worth, at $3 per ton, $1,980,000; besides linters to the value of a million or more dollars.

The following diagram, prepared by Grimshaw on the basis of the actual results at oil mills, shows how a ton of cotton seed is utilized:

*Products from a ton of cotton seed.*



The above diagram was prepared several years ago. Recently the processes of manufacture have been so improved that over 300 pounds (40 to 45 gallons) of oil can be obtained from each ton of seed, and delinting machines have been introduced which remove a much larger amount of linters than is given in this diagram, the proportion of hulls being correspondingly reduced.

As yet, only about one-third of the annual crop of cotton seed is taken to the mills. This is largely due to the lack of transportation facilities. No plan has been devised to preserve cotton seed
ing when stored in large quantities. It must, therefore,

by speading it over a floor with free access of air, exposing it on frames to the sunlight in warm weather, or by kiln-drying. Drying is the exception rather than the rule in the United States. Cotton ginning is so carefully done that the seeds have little or no opportunity to become wet. Besides this, the seed is generally held at the gins for some time before it is sold to the oil manufacturer.

The first process in preparing the dry seed for the mill is to free it from dust. This is effected by shaking it in a screen or in drums lined with a fine metallic net and containing a strong magnet to which any iron nails will adhere, which are frequently present. From the drums the seeds drop into a gutter leading to a machine which removes the lint left by the gin. This is done by a gin constructed for the purpose, with saws closer together than the ordinary cotton gin. An average of 22 pounds of short lint is taken from a ton of the seed. This product, called "linters," is used in the manufacture of cotton batting. The cleaned seeds are then transferred to the sheller, which consists of a revolving cylinder containing 24 cylindrical knives and 4 back knives. The sheller revolves at great speed, and as the seed is forced between the knives the pericarp or hull is broken and forced from the kernel. The mixed shells and kernels are separated in a winnowing machine by a strong blast of air. This removal of the husk makes a vast difference in the meal cake, a desiccated or decorticated cake being five times more nutritous and wholesome than an undecorticated cake.

Being thus cleaned, shelled, and separated, the kernels are carried by a system of elevators to the upper story, and then passed down into the crusher rolls to be ground to flour.

After this crushing the meats drop into a conveyor, which delivers them to the heaters. These are large cast-iron steam-jacketed kettles provided with stirrers which keep the meats moving while they are being cooked. The duration of the cooking varies from twenty to thirty minutes, according to the condition of the kernels and the good judgment of the cook, a human quality here called for the first time to supplement the automatic mechanism that has conducted the seed to this point through all the various processes it has undergone in its journey from the seed house. The object of the cooking is to expand the oil in the meats and render it more fluid, and to drive off the water, which not only reduces the quality of the oil but is liable to work serious injury to the expensive cloths used to envelope the cakes in the press. Very dry meats may sometimes be cooked in twelve to eighteen minutes, while fresh seeds may require forty-five minutes. Close to the heaters stands the "former," which shapes the meats into cakes for the press. The cakes as they come from the former are wrapped in haircloth and removed by hand to the press, where they are arranged in a series of boxes, one above the other, between the plates of the press, and subjected to a pressure of 3,000 to 4,000 pounds to the square inch by hydraulic power. The cakes, pressed as solid as boards, are taken from the press, stripped of the cloths, and stacked to dry. When dry they are passed through a cake cracker, which breaks them into fragments of a size suitable to be fed to a mill. The mill grinds these fragments into a fine meal, which is put up into sacks containing 100 pounds. Sometimes the meal is bolted to separate it from small pieces of the hull, which, being tough and leathery, are not readily ground up.

## COTTON-SEED OIL.

Notwithstanding the use of cotton as a textile material in the remotest days, there is no early record of the extraction of oil from the seed. The Chinese and the cotton growers of India ground the whole seed in rude mills and fed the cake to their work oxen, and such oil as was extracted by this operation was used for illumination. Among Western nations, perhaps the first mention of cotton-seed oil is to be found in the Proceedings of the Society of Arts, Manufactures, and Commerce for the year 1783, where it is stated that seed from the West Indies had been crushed in a mill in London and the oil extracted. The result was so satisfactory that the society offered a prize to any planter in the British West Indies who would express oil from a ton of seed and make 5 hundredweight of dry, hard cake for cattle food from the residue after extracting the oil. This offer was discontinued after six years of fruitless effort to find a claimant for the prize. In 1826 an oil mill was used in Columbia, S. C., which expressed from cotton seed a very good oil. About 1832 a small cotton-oil mill was operated on one of the islands on the Georgia coast. A Mr. Good engaged in the manufacture of oil in New Orleans in 1847, and used to exhibit a small bottle of cotton-seed oil which he said had cost him $12,000. In 1860 there were 7 establishments for the manufacture of cotton-seed oil in the United States; in 1867 there were 4 oil mills in the South, and from that time they increased rapidly in numbers, there being 26 in 1870, and 45 in 1880; but it was not until after the latter date that the cotton-seed oil industry approached its present large proportions.

To give some idea of the scale on which the cotton-seed oil industry is at present being conducted, the report of the American Cotton Oil Company in 1891 shows that with a capital of $33,761,700 it owned 72 crude-oil mills, 15 refineries, 4 lard and cottolene plants, 9 soap factories, 15 cotton ginhouses, 3 cotton compresses, 2 fertilizer mixing plants, 1 ocean tank steamship of 4,200 tons and 2,300 horsepower, 335 oil-tank cars, 23 box cars, and 1 barrel car, besides real estate, etc. The sale of their products for the year amounted to $23,879,400. The following table exhibits the growth of the cotton-seed oil industry in the United States:

*Statistics of the cotton-oil industry.*

| Year. | Establishments. | Capital. | Employees. | Wages. | Cost of materials. | Value of products. |
|---|---|---|---|---|---|---|
| 1860 | 7 | $351,000 | 183 | $75,956 | $498,000 | $741,000 |
| 1870 | 26 | 1,225,350 | 644 | 292,032 | 1,333,031 | 2,205,610 |
| 1880 | 45 | 3,862,500 | 3,114 | 880,830 | 5,091,251 | 7,690,921 |
| 1890 | 119 | .......... | 6,301 | 1,907,827 | 14,363,120 | 19,335,947 |
| 1894 | 252 | .......... | .......... | .......... | 18,000,000 | 30,000,000 |

A ton of cotton seed contains on the average about 50 gallons of oil, though the mills have thus far not been able to secure more than 45 gallons per ton. Even at the latter rate an annual crop of cotton seed mounting to 4,500,000 tons would yield 202,500,000 gallons of oil. Although only about one-third of the crop now reaches the mills, cotton-seed oil is produced in larger quantities than other vegetable oils. This oil finds ready sale in all the markets of the world.

In the United States the decorticated and crushed upland cotton seed yields by expression an odorless, dark, brownish-green oil, having a specific gravity varying from 0.92 to 0.93. After being treated with alkaline solutions a clear, yellow oil, which is odorless and of pleasant taste, is racked off. The residue is called soap stock. The refined oil boils at about 600° F. and congeals at about 50° for summer and 32° for winter pressed oil. American seed yields a clearer oil than the Egyptian or Indian seed, and the uplands seed produces a clearer oil than that from our seacoast. The oil made in Great Britain is not so clear as ours, first, because the seed is mostly Egyptian or Indian, and secondly, because it has not been decorticated. The climate has much to do with its quality of the oil. In some years, owing to more favorable weather conditions, the oil obtained from the seed grown in the western section of the cotton belt is better than that grown in the eastern section, while in other years it is just the reverse. It has been observed at cotton-seed oil mills that in general seed in a wet season contains more oil of poorer quality than in a dry season, but little is known of the change in its composition due to different conditions. It is safe to say that nine-tenths of the oil annually produced in the United States enters into the composition of food products, principally lard substitutes and salad and cooking oils. In pharmaceutical preparations it takes the place of olive oil. It is also used in the packing of sardines and for many other purposes as a substitute for olive oil. By reason of its imperfect drying properties it can not be used as a wood filler, nor for the stuffing of hides in the manufacture of morocco and other leathers. For the same reason it is debarred from use in paints. The refined oil is used to a considerable extent as a lubricant.

In the process of refining, the impurities in suspension are usually allowed to settle, and the clear supernatant oil is drawn off. To the latter from 10 to 15 per cent of caustic soda (10°–28° Baumé), according to the nature of the oil, is added, and the mixture agitated at a temperature of 100°–110° F. for forty-five minutes, the precipitate being allowed to settle from six to thirty-six hours. The residues obtained are disposed of as soap stock, in the manufacture of stearin, etc.

"The yellow oil resulting from this process is further purified by being heated and allowed to settle again, or by filtration, and is called summer yellow oil. Winter yellow oil is made from the above material by chilling it until it partially crystallizes and separating the stearin formed, about 25 per cent, in presses similar to those used for lard."[1] The latter constitutes the true cotton-seed stearin of commerce and is largely used in the preparation of butter and lard surrogates and candles.

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[1] H. W. Wiley, U. S. Dept. Agr., Division of Chemistry Bul. 13, p. 412.

Another substance, improperly called cotton-seed stearin, is obtained ling with superheated steam the mixture of organic acids formed when t acid is made to decompose the 'foots' obtained during the process of refin seed oil by alkalies, and pressing out the 'olein' from the distillate aft and solidification.—(Wright.)

For the preparation of the white oil of commerce the y obtained as above is shaken up with 2 to 3 per cent of fullers' e filtered.

As a food cotton-seed oil was first used as an adulterant to so temper lard intended for use in cold climates. Later on the fluid oil itself was corrected by mixing it with beef fat. This mixture on the market under the name of compound or refined lard. I kindly received by the public that before long all disguise was and it was sold on its merits in competition with lard. The importance of this food stuff as an article of commerce is indi the fact that while the exportation of lard only increased 37 between 1884 and 1893, that of cotton-seed oil and its co increased 162 per cent.

The soap made from cotton-seed oil is claimed to be especially to wool washing and is now largely used by the woolen mills country and also extensively in England and Scotland. The also been found to be excellent for laundry, family, and fancy

Another by-product in the manufacture of cotton-seed oil is powder made from the soap stock, which, however, owes its virtue to the soda or potash used in the refining processes.

## COTTON-SEED MEAL.

Cotton-seed meal, as has been already explained, is the grou due or cake left after the extraction of the oil by pressure. It i yellow in color when fresh, with a sweet, nutty flavor, but beco colored and deteriorates with age. The black specks seen samples show either an accidental impurity or an intentional a tion with hulls. Its composition depends upon the compositio seed and on the completeness with which the hulls and ker separated and the oil expressed. Improvements in oil machi constantly reducing the percentage of oil left in the cake. The ing table gives a summary of the results of over 400 analyses of seed meal with reference to food constituents, and probably sho accurately the average composition of decorticated cotton-seed found in the American market at the present time:

*Food constituents of cotton-seed meal.*

| | Fresh, or air-dry, material. | | | | |
|---|---|---|---|---|---|
| | Water. | Ash. | Protein. | Fiber. | Nitrog- fre extrac |
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per* |
| Minimum | 5.29 | 1.72 | 23.27 | 1.88 | [illegible] |
| Maximum | 18.52 | 10.62 | 52.88 | 15.15 | [illegible] |
| Average | 8.52 | 7.02 | 43.26 | 5.44 | [illegible] |

As will be seen by the table, cotton-seed meal is poor in carbohyates (starch, sugar, etc.), but is rich in fat and protein (nitrogenous tter). In fact, it is so rich in the latter constituent that it can be ilized to advantage as a food for animals only when mixed with some arse fodder rich in carbohydrates, thus furnishing a more evenly lanced ration.

In comparative valuations of feeding stuffs it has been found that tton-seed meal exceeds corn meal by 62 per cent, wheat by 67 per nt, and raw cotton seed by 26 per cent. As regards digestibility, tton-seed meal compares very favorably with other concentrated feed- stuffs, as the following statement of the amounts of digestible food redients in 100 pounds of meal will show: Protein, 37.01 pounds; bohydrates, 16.52, and fat, 12.58.

otton-seed meal is extensively used as a fertilizer, and for this pure it is worth from $20 to $25 per ton, determining the price on the ne basis as that used in calculating the value of other commercial tilizers. It frequently happens, even in Northern States, that cotton-d meal can be bought for less than its fertilizing value, calculated the above basis. Its composition with reference to fertilizing connents is shown by the following summary of results of 204 analyses:

*Fertilizing materials in cotton-seed meal.*

| | Water. | Ash. | Nitrogen. | Phosphoric acid. | Potash. |
|---|---|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| num | 4.34 | 3.35 | 3.23 | 1.26 | 0.87 |
| um | 12.57 | 9.90 | 8.08 | 4.62 | 3.32 |
| age | 7.81 | 6.95 | 6.79 | 2.88 | 1.77 |

lthough cotton-seed meal contains considerable percentages of phosric acid and potash, a large proportion of which has been shown to eadily available to plants, it is chiefly used as a source of nitrogen rtilizers. Storer states that "experience has shown that cotton- meal is usually as good a fertilizer as regards its nitrogen as either fish or flesh scrap, provided the land is not too dry." Cotton-seed has given excellent results, especially in the Southern States, as tilizer for sugar cane, cotton, and corn. It has also been success- substituted for barnyard manure in the culture of tobacco.

hile cotton-seed meal, as the above facts show, has high value applied directly as a fertilizer, a more rational practice in many is to feed the meal to animals and apply the resulting manure to oil. From 80 to 90 per cent of the fertilizing materials of the meal thus be recovered in the manure, and additional benefit will be ed in the production of meat, milk, etc.

## COTTON-SEED HULLS.

tton-seed hulls, as we have already seen, constitute about half the ht of the ginned seed. Analysis shows them to be principally crude fiber and nitrogen-free extract matter, these two constituen with water, constituting more than 90 per cent of the hulls. Hulls ev from the same mill, however, vary widely in composition, owing t imperfect removal of the lint or the adherence of more or less of th kernel. The following table shows the minimum, maximum, and ave age composition of the hulls, compiled from 22 analyses:

*Food constituents of cotton-seed hulls.*

| | Fresh, or air-dry, material. | | | | | |
|---|---|---|---|---|---|---|
| | Water. | Ash. | Protein. | Fiber. | Nitrogen-free extract. | Fat. |
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cen* |
| Minimum | 7.25 | 1.65 | 2.78 | 35.75 | 12.41 | 0. |
| Maximum | 16.73 | 4.43 | 5.37 | 66.95 | 41.24 | 5. |
| Average | **11.86** | **2.73** | **4.18** | **45.32** | **34.19** | **2.** |

The hulls are hard and dry, and usually covered with a fuzzy lint. On superficial examination they appear to be a most unpromising food material, and, in fact, until a comparatively recent period they were universally considered worthless for this purpose.

At least as early as 1870, i. e., soon after the introduction of the oil industry, we have good evidence of local and individual cases of feeding the cotton-seed hulls to live stock. But probably the first attempts at systematically feeding an exclusive ration of hulls and meals on a large scale were made [about 1883]. These cases have been local, confined to the vicinities of the oil manufacturing centers like Memphis, New Orleans, Houston, Little Rock, Raleigh, and Atlanta.—(Stone.)

There are several points in their favor, especially convenience of handling and cheapness. They form a handy medium to dilute condensed food, and give that extension to the animal stomach, especially to ruminating animals (cud-chewing), which is regarded so essential to good, healthy digestion.—(Kilgore.)

They have been found to be a cheap and effective substitute for hay.

Digestion experiments have indicated that 10 per cent of the protein of cotton hulls is digestible, 38 per cent of the fiber, 40 per cent of the nitrogen-free extract, and 77 per cent of the fat; so that 100 pounds of hulls contains the following amounts of digestible food constituents: Protein, 0.42 pounds; carbohydrates (including fiber and nitrogen-free extract), 30.95 pounds, and fat, 1.69 pounds.

The hulls are so bulky as to make storage difficult and they are liable to heat when kept in bulk. For this reason it is usual to put them up into bales weighing 85 to 90 pounds. Baling, as at present practiced, costs about 90 cents a ton, but the hulls keep well and are easily handled. They are sometimes pressed into sacks and preserved in that way, or, before baling and sacking, they may be mixed with definite quantities of cotton-seed meal, bran, cracked corn, or other feeding stuff, to be disposed of as a prepared stock food.

Hitherto a large proportion of the hulls have been used for fuel in the engines at the mills. Their value for fuel is estimated at 80 to 90 cents ion where good pine wood is to be had at $2 a cord or coal at $3.50 a ton. In other words, a cord of wood is equal in heating power to 2½ tons of hulls, and a ton of coal to 4½ tons of hulls.

### COTTON-HULL ASHES.

Cotton-hull ashes have been on the market since 1880 and have come into great demand as a cheap potash supply, especially among tobacco growers. The quality of these ashes varies greatly on account of impurities introduced, principally by the use of other fuel with the hulls. The following table gives a summary of 185 analyses of this material:

*Fertilizing constituents in cotton-hull ashes.*

| | Water | Phosphoric acid. | Potash. | Lime. | Magnesia. | Carbonic acid. |
|---|---|---|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Minimum | 0.25 | 2.37 | 7.02 | 0.86 | 2.85 | 9.56 |
| Maximum | 22.30 | 15.37 | 44.72 | 19.35 | 17.15 | 11.59 |
| Average | **9.00** | **9.08** | **23.40** | **8.85** | **9.97** | **10.57** |

The potash exists largely as carbonate, which is readily available to plants, but there is also a considerable percentage of silicate of potash, which is difficultly available. The value of cotton-hull ashes depends almost exclusively upon the amounts of potash and phosphoric acid they contain.

### FEEDING COTTON-SEED PRODUCTS TO FARM STOCK.

Practical experience has been supplemented by carefully conducted experiments, both in the United States and Europe, with cotton seed, cotton-seed hulls, and cotton-seed meal as food for cattle, sheep, pigs, horses, and mules, with the result of demonstrating their high feeding value for all kinds of farm stock, with the possible exception of calves and pigs, to which they have frequently proved fatal.

The high feeding value of whole cotton seed has long been recognized, having been fed raw, roasted, steamed, or boiled to live stock, especially to cattle. Almost from the beginning of cotton culture in this country it has been used to some extent as a feeding stuff, but since the introduction of the cotton-oil industry the superior feeding quality of the by-product—cotton-seed meal—has led to a very general displacement of whole seed by the meal in localities where the latter is easily and cheaply obtained.

The value of cotton-seed meal for producing meat, milk, and butter is well established. It is one of the cheapest of the highly nitrogenous feeding stuffs and is therefore one of the most economical for balancing rations deficient in protein, such as those in which corn is the principal grain. As the analyses on page 10 show, it is very concentrated and should be fed in comparatively small quantities in connection with a great danger. Its effect on horses and mules has not as yet been sufficiently studied to warrant conclusions, but a few instances are reported in which it has been fed regularly for long periods with good results.

### SUMMARY.

Cotton stands preeminent among farm crops in the ease and cheapness of its production as compared with the variety and value of its products.

The amount of soil fertility actually removed in a crop of cotton, even when both seed and lint are sold, is smaller than that removed by either corn or oats, and when care is taken to return the seed or an equivalent in meal to the soil these losses are almost insignificant.

Cotton roots furnish a useful drug; the stems and leaves together have a certain value as fodder, and the stems alone have been utilized with some success for fiber and for fuel; but next in importance to the lint stands the seed, which furnishes a great variety of valuable products whose applications are being rapidly extended.

The 1,500,000 tons of seed worked at the oil mills during the season of 1893–94 could have been made to produce under favorable conditions in round numbers 67,000,000 gallons of crude oil, worth, at 25 cents per gallon, $16,750,000; 600,000 tons of meal, worth, at $20 per ton, $12,000,000; 660,000 tons of hulls, worth, at $3 per ton, $1,980,000; besides linters to the value of a million or more dollars.

The oil is the main product of the seed. The larger portion of the oil manufactured in this country is used in the preparation of food products, principally refined lard and salad and cooking oils. It is also used in the manufacture of soaps of various kinds, washing powder, cosmetics, to some extent for illuminating purposes, as a lubricant (when refined) in the manufacture of bolts and nuts, and generally as a substitute for olive oil. The fact that it is not strictly a drying oil, however, renders it unfit for use in paints. The refuse from the refining of the oil is valuable "stock" for the manufacture of soap.

The residue (cake) after the removal of the oil is a valuable fertilizer and feeding stuff, the hulls excellent fuel, the ashes of the hulls a fertilizer rich in potash and phosphoric acid. The seed also furnishes a dyestuff which has been used to some extent.

It is believed that an increased knowledge of the nature and value of the products of cotton seed will extend their use until it will be found profitable to work up the whole available crop of seed into commercial products instead of utilizing in this way only about one-third of the crop, as is now the case.

○

P. P.—50.

U. S. DEPARTMENT OF AGRICULTURE.

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FARMERS' BULLETIN No. 38.

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# RAYING FOR FRUIT DISEASES.

BY

B. T. GALLOWAY,

Chief of Division of Vegetable Physiology and Pathology.

LANE MEDICAL LIBRARY
SAN FRANCISCO

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GOVERNMENT PRINTING OFFICE.
1896.

## FARMERS' BULLETINS.

These bulletins are sent free of charge to any address upon appl tion to the Secretary of Agriculture, Washington, D. C.

[Only the bulletins named below are available for distribution.]

No. 15. Some Destructive Potato Diseases: What They Are and How to Pre Them. Pp. 8.
No. 16. Leguminous Plants for Green Manuring and for Feeding. Pp. 24.
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No. 55. The Dairy Herd: Its Formation and Management. Pp. 24.
No. 56. Experiment Station Work—I. Pp. 32.
No. 57. Butter Making on the Farm. Pp. 15.

# LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY,
*Washington, D. C., March 17, 1896.*

SIR: I have the honor to transmit herewith for publication a Farmers' Bulletin on spraying for fruit diseases. The object of this bulletin is to bring together, in concise, practical form, the results of recent investigations and experiments in the treatment of some of the more common fungous diseases of fruits.

Respectfully,

B. T. GALLOWAY,
*Chief of Division.*

HON. J. STERLING MORTON,
*Secretary of Agriculture.*

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# SPRAYING FOR FUNGOUS DISEASES.

## INTRODUCTION.

It is four years since there was published, in Farmers' Bulletin No. 7, a summary of the more important methods of combating some of the destructive diseases of fruits. During this time many improvements have been made in the work, and for this and other reasons it seems desirable to now bring together, in brief, practical form, our present knowledge on the subject. The question as to whether it will pay to spray has long since been answered in the affirmative, so it is not necessary at this time to enter upon any argument in regard to this phase of the subject. It is furthermore not necessary to go into detail as to the relation of spraying to hygiene. Suffice it to say that if the work is properly done no danger whatever to health need be apprehended.

## FUNGICIDES OR REMEDIES FOR PLANT DISEASES.

During the past four years numerous solutions, powders, etc., have been tested, with a view of determining their value as economical, effective, and practical preventives of fungous parasites. While a number of these preparations have given promise of value, none have been found which fill so many requirements as bordeaux mixture and the ammoniacal solution of copper carbonate. Of the two preparations, bordeaux mixture has long been recognized as possessing the most valuable qualities, and it is probably more generally used to-day than all other fungicides combined. The chief points in its favor are, (1) its thorough effectiveness as a fungicide, (2) its cheapness, (3) its safety from a hygienic standpoint, (4) its harmlessness to the sprayed plant, and (5) its beneficial effects on plants other than those resulting from the mere prevention of the attacks of parasites.

So far as we are concerned, therefore, it is necessary to consider only the two fungicides in question, setting forth the recent improvements made in preparing and using them.

### BORDEAUX MIXTURE.

All things considered, it is believed that the best results will be obtained from the use of what is known as the 50-gallon formula of this preparation. This contains—

| | |
|---|---|
| Water | 50 gallons. |
| Copper sulphate | 6 pounds. |
| Unslacked lime | 4 pounds. |

w necessary to determine whether the mixture is perfect—that ill be safe to apply it to tender foliage. To accomplish this, le tests may be used. First insert the blade of a penknife xture, allowing it to remain there for at least one minute. If copper forms on the blade, or, in other words, if the polished e of the umes the f copper e mix- safe and ne must l. If, on er hand, e of the nains un- it is safe ide that ure is as s it can As an l test, however, some of the mixture may be poured into an or saucer, and while held between the eyes and the light the hould be gently blown upon the liquid for at least half a minute. ixture is properly made, a thin pellicle, looking like oil on water, will begin to form on the surface of the liquid. If no pellicle forms, more milk of lime should be added.

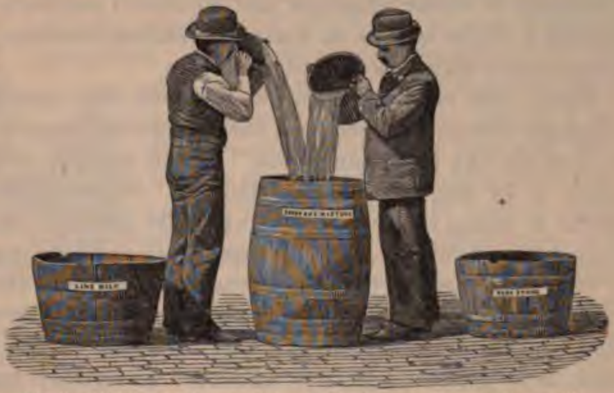
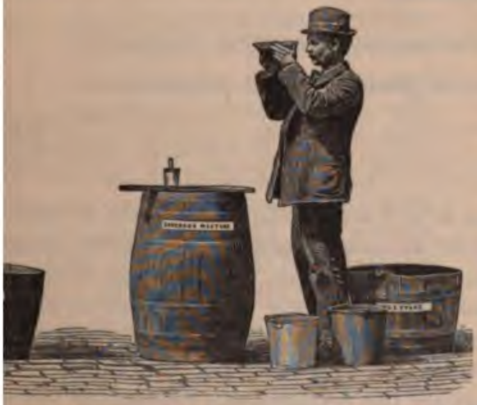


FIG. 2.—Making bordeaux mixture: Pouring together the lime milk and copper sulphate solution.



'esting bordeaux mixture: The saucer or plate method and the knife method.

The foregoing directions apply to cases where small quantities of the mixture are needed for more or less immediate use. If spraying is to be done upon a large scale, it will be found much more conveni- economical in every way to prepare what are known as stock s of both the copper and lime. To prepare a stock solution of ulphate, procure a barrel holding 50 gallons. Weigh out 100 of copper sulphate, and after tying it in a sack suspend it so that ang as near the top of the barrel as possible. Fill the barrel ter, and in two or three days the copper will be dissolved.

$10 or $12. The horse-power sprayers will cost all the way from $25 to $125 each.

There are many farmers and others who grow a miscellaneous line of fruits, such as a few grapes, pears, apples, etc.; in such cases it is desirable to have an inexpensive and effective apparatus that will answer for the various crops. Such an apparatus is shown in fig. 5. As will be seen, it consists of a small force pump provided with a long piece of discharge hose and a cyclone nozzle. The whole outfit can be purchased and put together for $5, and it will be found in every way superior to the many forms of syringes on the market. The pump is strong and durable, and although small it will throw a solid stream, the size of a lead pencil, for more than 30 feet. It may be used for trees of all kinds, as well as for vines and low-growing crops.

Passing now to the methods of treatment proper, we may consider first some of the more important diseases of the grape.

## TREATMENT OF GRAPE DISEASES.

The principal diseases affecting the grape east of the Rocky Mountains are black rot, downy mildew, powdery mildew, and anthracnose.

### BLACK ROT.

Clean the vineyard thoroughly in the spring, burning all trimmings, rotten berries, dead leaves, etc. When the buds begin to open spray with bordeaux mixture, taking care to wet the new growth and fruit-bearing wood. In ten or twelve days make a second spraying, and follow this with a third as soon as the fruit is well set. In case of rainy weather, additional treatments should be made, at intervals of twelve or fifteen days, until the fruit begins to show signs of ripening. In an average season six treatments are usually necessary to hold the disease in check. In case of much rain, however, eight sprayings would better be given.

As a modification of the foregoing treatment, the first three applications may be made with bordeaux mixture, while for the others the ammoniacal solution may be used. The only advantage in this case is that there is not so much likelihood of having stained fruit at the harvest. If the bordeaux mixture is properly made and applied, there need be little trouble from this source.

### DOWNY MILDEW.

Downy mildew may be successfully combated by the methods recommended for black rot. In fact, where the two diseases occur together, as they do to a greater or less extent throughout the grape-growing regions of the eastern United States, treatment for the one will answer for the other. In some sections downy mildew and brown rot of the berries, which are due to the same fungus, occur alone, and in such cases the ammoniacal solution will be found an effective remedy. The fungus wny mildew and brown rot usually comes on later than the one ng black rot, and for this reason the treatments need not begin so where downy mildew occurs alone. The first spraying should be soon after the fruit forms, and other applications should follow ervals of twelve or fifteen days, as recommended for black rot.

### POWDERY MILDEW.

is disease seldom does much injury, as it usually comes on late e season. In regions where it is known to prevail every year, cations of ammoniacal solution will doubtless hold the parasite in . Flowers of sulphur has also been extensively used; in fact, on acific Coast and in grap- this is almost the only dy applied.

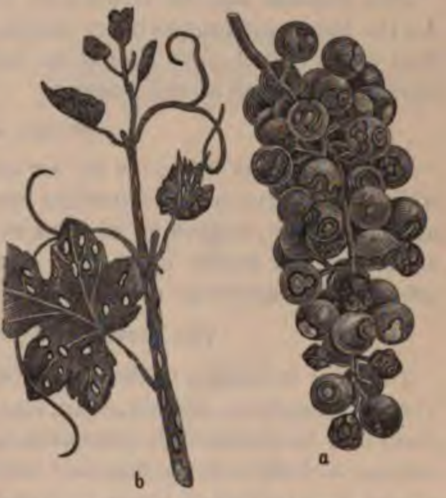


FIG. 6.—Anthracnose of grape leaves, stem, and berries.

### ANTHRACNOSE.

is is quite a serious disease me sections, and as yet has ielded as readily to treat- as other grape maladies. directions given for black hould be followed in com- g this disease, using bor- x mixture throughout the . In addition, the vines d be carefully examined e the leaves put out, and ever the large scars (fig. oduced by the fungus, are they should be cut out. results have followed the use of a strong solution of iron sulphate ed to the wood during the winter. The solution may be made uring a pint of sulphuric acid upon 25 pounds of iron sulphate, hen slowly adding 50 gallons of water. In no case should this ration be used after growth starts.

## TREATMENT OF APPLE DISEASES.

the several diseases of the apple amenable to fungicidal treat- , scab, bitter rot, and the powdery mildew may be mentioned as bly the most serious.

### APPLE SCAB.

e bordeaux mixture, making the first application before the blos- open. When the flowers are opening spray again, then a third when the fruit is about the size of a pea. After this two or treatments should be made, the number depending somewhat he variety treated, the weather conditions, etc. Ordinarily, five

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## FARMERS' BULLETIN No. 41.

# WLS: CARE AND FEEDING.

BY

G. C. WATSON, B. Agr., M. S.,

Professor of Agriculture in Pennsylvania State College and Agriculturist
of the Pennsylvania Agricultural Experiment Station.

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# FOWLS: CARE AND FEEDING.

## INTRODUCTION.

The wide distribution of domestic fowls throughout the United States and the general use made of their products make poultry of interest to a large number of people. Breeders are continually striving to improve the fowls for some particular purpose, and to excel all predecessors in producing just what the market demands for beauty or utility; but the mass of people look at the poultry products solely as supplying the necessary elements of food in an economical and palatable form. For a considerable time each year eggs are sought instead of meat by people of moderate means, because at the market price eggs are a cheaper food than the various kinds of fresh meat.

Large numbers of the rural population live more or less isolated, and find it inconvenient, if not impossible, to supply fresh meat daily for the table aside from that slaughtered on the farm; and of all live stock poultry furnishes the most convenient means of supplying an excellent quality of food in suitable quantities. This is particularly true during the hot summer months, when fresh meat will keep only a short time with the conveniences usually at the farmer's command.

The general consumption of poultry and poultry products by nearly all classes of people furnishes home markets in almost every city and town in the United States, and at prices which are usually remunerative if good judgment is exercised in the management of the business.

Although fowls require as wholesome food as any class of live stock, they can be fed perhaps more than any other kind of animals on unmerchantable seeds and grains that would otherwise be wholly or partially lost. These seeds often contain various weed seeds, broken and undeveloped kernels, and thus furnish a variety of food which is always advantageous in profitable stock feeding. There is less danger of injury to poultry from these refuse seeds than is the case with any other kind of animals. As a rule, noxious weed seeds can be fed to fowls without fear of disseminating the seeds through the manure, which is not generally true when the weed seeds are fed to other classes of live stock, particularly in any considerable quantity.

## SELECTION OF SITE FOR BUILDINGS AND YARDS.

Too often the location of the poultry house is thought to be of minor importance, and consequently is given less consideration than that of any other farm building. Frequently the other buildings are located dition will be nearly approached. Where natural favorable conditions as to drainage do not exist, thorough underdrainage will go a long way toward making the necessary amends to insure success.

## CONSTRUCTION OF HOUSES.

The material to be used in the construction and the manner of building will necessarily be governed largely by the climatic conditions.

In general, it may be said that the house should provide warm, dry, well-lighted, and well-ventilated quarters for the fowls.

In order to meet these requirements it will be necessary to provide a good roof with side walls more or less impervious to moisture and cold, suitable arrangements for lighting and ventilating, and some means for excluding the moisture from beneath. Where permanent buildings are to be erected, some provision should be made to exclude rats and mice, and for this reason, if for no other, the structure should be placed on cement walls with foundation below the frost line. Cheap, efficient walls may be made of small field stone in the following manner: Dig trenches for the walls below the frost line; drive two rows of stakes in the trenches, one row at each side of the trench, and board inside of the stakes. The boards simply hold the stones and cement in place until the cement hardens. Rough and uneven boards will answer every purpose except for the top ones, which should have the upper edge straight and be placed level to determine the top of the wall. Place two or three layers of stone in the bottom of the trench, put on cement mixed rather thin, and pound down; repeat this operation until the desired height is obtained. The top of the wall can be smoothed off with a trowel or ditching spade and left until the cement becomes hard, when it will be ready for the building.

The boards at the sides may be removed, if desirable, at any time after the cement becomes hard.

For the colder latitudes, a house with hollow or double side walls is to be preferred on many accounts, although a solid wall may prove quite satisfactory, particularly if the building is in the hands of a skilled poultryman. Imperfect buildings and appliances, when under the management of skilled and experienced men, are not the hindrances that they would be to the amateur. Buildings with hollow side walls are warmer in winter and cooler in summer, with less frost in severe weather, and less resulting moisture when the temperature moderates sufficiently to melt the frost from the walls and roof of the house.

A cheap, efficient house for latitudes south of New York may be made of two thicknesses of rough inch lumber for the side and end walls. This siding should be put on vertically, with a good quality of tarred building paper between. In constructing a building of this kind, it is usually best to nail on the inner layer of boards first; then put on the outside of this layer the building paper in such a manner that the whole surface is covered. Where the edges of the paper meet, a liberal lap should be given, the object being to prevent as far as drafts of air in severe weather. Nail the second thickness o on the building paper so as to break joints in the two boardi selecting lumber for siding, it is best to choose boards of a width to facilitate the breaking of joints.

In constructing a roof for a house in the colder latitudes or courses must be pursued, either to ceil the inside with some to exclude drafts or to place the roof boards close together a thoroughly with tarred paper before shingling. The ordinar roof is too open for windy weather when the mercury is at or l zero mark. The fowls will endure severe weather without from frosted combs or wattles if there are no drafts of air. I lay well during the winter n the houses are warm enough the single-comb varieties do n from frost bite. Whenever th or wattles are frozen, the los creased egg production can other than serious.

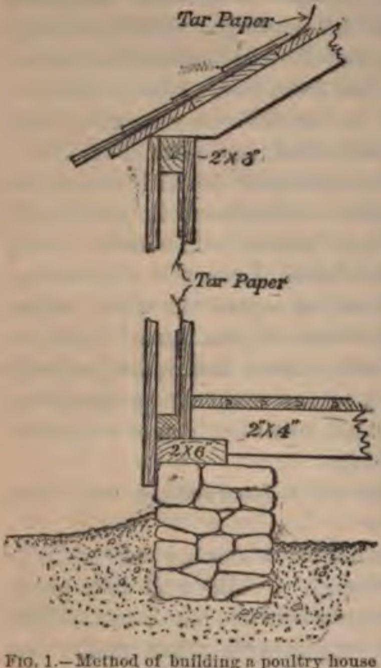

FIG. 1.—Method of building a poultry house with hollow side wall.

Figure 1 represents a che efficient method of building a house with a hollow side wa sill may be a 2 by 6 or 2 by 8 sc laid flat on the wall or found 2 by 2 strip is nailed at the out to give the size of the space b the boards which constitute t walls. A 2 by 3 scantling se wise forms the plate, and to t boards of the side walls are These boards may be of rough if economy in building is desi so, the inner boarding should b on first and covered with tarre ing paper on the side that wi within the hollow wall when th ing is completed. This building paper is to be held in place wi or strips of thin boards. If only small nails or tacks are used, th will tear around the nail heads when damp and will not stay in

The cracks between the boards of the outside boarding may ered with inexpensive battens if they are nailed at frequent in with small nails. Ordinary building lath will answer this admirably, and will last many years, although they are not so as heavier and more expensive strips. The tarred paper on th boarding and the battens on the outside make two walls, each vious to wind, with an air space between them.

In preparing plans for a building, one of the first questions to be decided upon is the size and form of the house. If the buildings are made with the corners right angles, there is no form so economical as a square building. This form will inclose more square feet of floor space for a given amount of lumber than any other, but for some reasons a square building is not so well adapted for fowls as one that is much longer than wide. It is essential to have the different pens or divisions in the house so arranged that each one will receive as much sunlight as possible, and to secure this, some sacrifice in economy of building must be made.

The writer prefers a building one story high, and not less than 10 nor more than 14 feet wide, and as long as circumstances require. In most cases a building from 30 to 60 feet long meets all requirements. If this does not give room enough, it is better to construct other buildings than to extend one building for more than 60 feet. It must be remembered that each pen in the building should have a separate yard or run, and that a pen should not be made to accommodate more than 50 fowls, or, better, 30 to 40.

The building should extend nearly east and west in order that as much sunshine as possible may be admitted through windows on the south side. The windows should not be large nor more than one to every 8 or 10 feet in length for a house 12 feet wide, and about 17 inches from the floor, or at such height that as much sunshine as possible will be thrown on the floor. The size and form of the windows will determine quite largely their location. In all poultry houses in cold latitudes the windows should be placed in such a position that they will give the most sunshine on the floor during the severe winter months. One of the common mistakes is in putting in too many windows. While a building that admits plenty of sunlight in the winter time is desirable, a cold one is equally undesirable, and windows are a source of radiation at night unless shutters or curtains are provided. Sliding windows are preferred on many accounts. They can be partially opened for ventilation on warm days. The base or rail on which the window slides should be made of several pieces fastened an inch or so apart, through which openings the dirt which is sure to accumulate in poultry houses may drop and insure free movement of the window.

## VENTILATION.

Some means of ventilating the building should be provided. A ventilator that can be opened and closed at the will of the attendant will give good results if given proper attention, and without attention no ventilator will give the best results. All ventilators that are in continuous operation either give too much ventilation during cold and windy weather or not enough during still, warm days. As a rule, they give too much ventilation at night and too little during the warm parts of the day. Ventilators are not needed in severe cold weather, but during the first warm days of early spring, and whenever the temperature rises above freezing during the winter months some ventilation should be provided. Houses with single walls will become quite frosty on the inside during severe weather, which will cause considerable dampness whenever the temperature rises sufficiently to thaw out all the frost of the side walls and roof. At this time a ventilator is most needed. A ventilator in the highest part of the roof that can be closed tightly by means of cords or chains answers the purpose admirably and may be constructed with little expense. The ease and convenience of operation are important points, and should not be neglected when the building is being constructed. It is a simple matter for the attendant to open or close a ventilator as he passes through the house if the appliances for operating it are within easy reach. Figure 2 represents an efficient and easily operated ventilator.

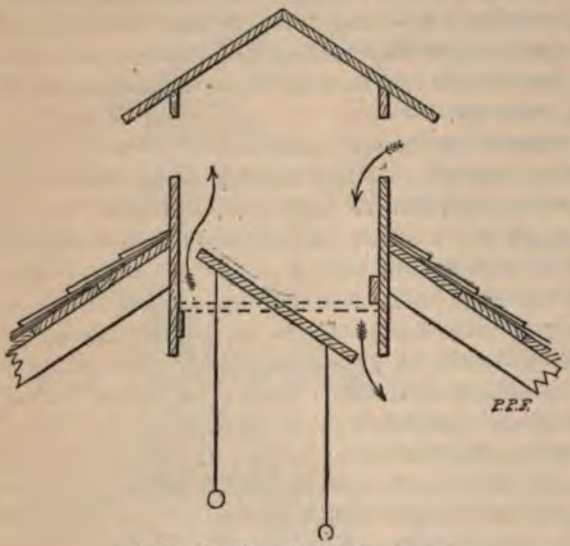

FIG. 2.—Ventilator for a poultry house.

PERCHES.

Perches should be not more than 2½ feet from the floor, and should all be of the same height. Many fowls prefer to perch as far above the ground as possible, in order, without doubt, to be more secure from their natural enemies; but when fowls are protected artificially from skunks, minks, foxes, etc., a low perch is just as safe and a great deal better for the heavy-bodied fowls. It must be borne in mind that the distance given at which perches should be placed from the floor applies to all breeds of fowls. It is true that some of the Mediterranean fowls would not in any way be injured in flying to and from the perches, but some of the heavy breeds would find it almost impossible to reach high perches and would sustain positive injuries in alighting on the floor from any considerable elevation. Convenient walks or ladders can be constructed which will enable the large fowls to approach the perches without great effort, but there are always times when even the most clumsy fowls will attempt to fly from the perch to the floor and come down with a heavy thud, which is often injurious. And furthermore, ladders or stairs for the easy ascent of [illegible]ls are more or less of a nuisance in the poultry house. The ideal interior arrangement of the house is to have everything that is needed in as simple a form as possible and not to complicate the arrangement by any unnecessary apparatus. The fewer and simpler the interior arrangements the easier the house can be kept clean, and the greater the floor space available for the fowls.

There is no reason why all perches should not be placed near the floor. Movable perches are to be preferred. A 2 by 3 scantling set edgewise, with the upper corners rounded, answers every purpose and makes a satisfactory perch. The perches should be firm and not tip or rock. The form of the scantling makes it easy to secure them firmly and still have them removable.

Underneath the perches should always be placed a smooth platform to catch the droppings. This is necessary for two reasons: the droppings are valuable for fertilizing purposes and ought not to be mixed with the litter on the floor; then, too, if the droppings are kept separate and in a convenient place to remove, it is much easier to keep the house clean than when they are allowed to become more or less scattered by the tramping and scratching of fowls. The distance of the platform from the perch will be governed somewhat by the means employed for removing the droppings. If a broad iron shovel with a tolerably straight handle is used, the space between the platform and perches need not be more than 6 inches. The droppings should be removed every day.

### NESTS.

In constructing nest boxes, three points should be kept constantly in mind: (1) The box should be of such a nature that it can be readily cleaned and thoroughly disinfected; if it is removable so that it can be taken out of doors, so much the better; (2) it should be placed in the dark, or where there is only just sufficient light for the fowl to distinguish the nest and nest egg; (3) there should be plenty of room on two or three sides of the nest. It is a well-known fact that some hens in seeking a nest will always drive off other hens, no matter how many vacant nests may be available. If the nest is so arranged that it can be approached only from one side, when one hen is driving another from the nest there is likely to be more or less of a combat, the result of which is often a broken egg. This, perhaps, more than any other one thing, leads to the vice of egg eating. To the writer's knowledge, the habit of egg eating is not contracted where the nests are arranged in the dark and open on two or three sides. Nests for Leghorns or Hamburgs may be made of 6-inch fence boards nailed together so as to form boxes 8 by 10 inches and 6 inches deep. Where perches are arranged with the platform underneath to catch the droppings, as previously described, the nests may be placed on the floor underneath this platform, the opening in front closed with a door which either lets down from the top or lifts from the bottom. Where nests are placed side by side it is necessary to have the partitions between them of sufficient height so that it will be impossible for a hen to draw e one nest to another. Whenever the nest boxes are filled so nest material that a hen can draw an egg from one nest to some of the eggs are likely to be broken.

## DRINKING FOUNTAINS.

One of the difficult problems for the poultryman to solve easily provide pure, fresh water for his fowls. Many patent which are on the market are automatic and keep before th certain quantity of water. Under certain conditions these serve an admirable purpose. Under more adverse condition these patent contrivances fail to give satisfaction for the sim that it is impossible to keep them clean. If fowls were fed o grain and the weather was always cool, it would be a com easy matter to provide satisfactory automatic drinking foun as soft food forms a considerable portion of the diet for la and fattening fowls, these fountains are necessarily more or l and in warm weather soo unfit for use as drinking on account of the tainted disagreeable odor.

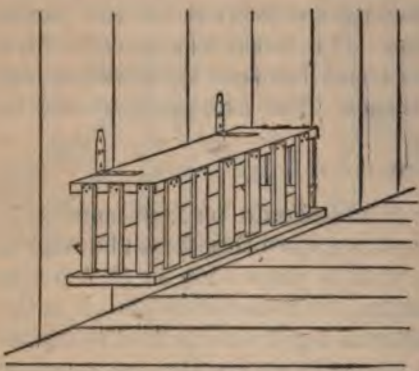

FIG. 3.—Drinking fountain.

A simple, wholesome ment may be made as follo an ordinary milk pan on shallow box, the top of w be 4 or 5 inches from The water or milk to be the fowl is to be placed in Over the pan is placed cover supported on piec about 8 inches long, nail cover so that they are about 2 inches apart, the lower ends rest the box which forms the support of the pan. In order to drink pan it will be necessary for the fowls to insert their heads these strips of lath. The cover over the pan and the strips the sides prevent the fowl from fouling the water in any mann in the act of drinking. Where drinking pans of this kind ar is very easy to cleanse and scald them with hot water as demands. This arrangement can be carried a little further b a pan, or, what would be still better, a long narrow dish, like a tin bread tray, on a low shelf a few inches from the hinging the cover to one side of the poultry house so that i tipped up in front for the removal of the dish or for fillin water. (See fig. 3.) Whatever device is used, it must be easi and of free access to the fowls at all times.

## DUST BOXES.

It is necessary to provide dust boxes for the fowls during the winter months if they are to be kept free from lice. If the soil in the yards is naturally dry and porous, abundant opportunities will be had for dust baths during the warm summer months, but during the late fall, winter, and early spring some artificial provision must be made. A comparatively small box will answer the purpose if the attendant is willing to give a little attention to it each day. These boxes should be placed so that they will receive some sunshine on each bright day, and be kept well filled with loose fine earth. Road dust procured during the hot, dry months of July and August from much-traveled roads has no superior for this purpose. Probably there is no way in which the poultry man can better combat the body louse than by providing dust boxes for his fowls.

## YARDS OR PARKS.

Where fowls are kept in confinement it will be found best to provide outdoor runs or yards for them during the summer months. Give them free access to these yards whenever the weather will permit. The most economical form, everything considered, for a poultry yard is one much longer than wide. Two rods wide and 8 rods long is sufficient for 50 fowls. Whenever a poultry plant of considerable size is to be established it will be found most economical to arrange the yards side by side, with one end at the poultry house. The fences which inclose these yards may be made of poultry netting or pickets, and should be at least 7 feet high. In either case it is best to have a board at the bottom, for sometimes it will be desirable to give quite young chickens the run of these yards. If the poultry yards are constructed as described, there is sufficient room for a row of fruit trees down the center of the yard, and still leave ample room for horse cultivation on either side, either with one or with two horses.

These yards are to be kept thoroughly cultivated. If thought best, grain may be sown before cultivation to furnish part of the green food for the fowls. Of all fruit trees, probably there are none that are more suitable for the poultry yard than the plum. The droppings of the fowls will manure the trees, and the fowls as insect destroyers perform a great office in protecting plums from the curculio. After the trees are once well established, a crop of plums should be secured nearly every year. These, too, will require no extra cultivation. The plum trees perform a valuable service in providing shade for the fowls. Where trees are not available, sunflowers may be used for this purpose with a considerable degree of satisfaction. However, some protection must be given the plants until they are well established, and even then many plants will be destroyed unless the fowls have an abundance of green food all the time.

Hamburgs and Leghorns, if they are frequently moved from
to another, will sometimes give the owner considerable troubl
ing over fences, even though they are 7 feet high. If it is pos
place the fowls when they are quite young in the yard where t
to remain, much less trouble will be experienced. It has oft
noticed that hens would remain peacefully in the yard where t
been reared, but if moved to another yard would give the own
or less trouble by flying over the inclosure.

## SELECTION OF BREEDS AND BREEDING.

A mistake is oftentimes made in selecting fowls of a breed th
suited for the purposes for which they are to be kept. If egg
tion is the all-important point, it is a most serious mistake to
breed of fowls that is not noted for this product. If, on the oth
meat is the chief object, an expensive mistake will be made if
the heavy-bodied fowls are chosen. The small, active, nervo
producing breeds can not compete with the larger phlegmatic
for meat production. Then, too, if fowls are kept for both e
meat production, some breed of the middle class should be
These, while they do not attain the great size of the Asiatics,
ciently large to be reared profitably to supply the table with m
at the same time have the tendency for egg production develo
ciently to produce a goodly number of eggs during the ye
Wyandottes and Plymouth Rocks are good illustrations of thi
fowls. While individuals of these breeds have made excellen
in egg production, the records of large numbers do not
favorably with the egg production of the Mediterranean fowls
the so-called Mediterranean fowls have a great tendency tow
production and require only the proper food and care to prod
in abundance.

A serious mistake is also made in selecting fowls for breed
poses and in selecting eggs for hatching. On many farms th
is to select eggs for hatching during the spring months, when
of the fowls are laying. No matter how poor a layer a hen
the chances are that most of the eggs will be produced du
spring and early summer months. A hen that has laid ma
during the winter months is quite likely to produce fewer egg
the spring and early summer months than one that commence
on the approach of warm weather. Springtime is nature's se
egg production. All fowls that produce any considerable nu
eggs during the year are likely to be laying at this time. It
fore plain that whenever eggs are selected in the springtime
flock of mixed hens, composed of some good layers and som
ones, a larger per cent of eggs will be obtained from the poo
than at almost any other season of the year. A serious mi
therefore made in breeding largely from the unprofitable fowls.
ever it is possible, fowls that are known for the great number

they have produced during the year should be selected for the breeding pen. While it will be almost impossible, and certainly impracticable, in the majority of cases to keep individual records of egg production, yet a selection may be made that will enable the breeder to improve his flock greatly.

The two things necessary to produce large quantities of eggs with the Mediterranean fowls are: (1) Proper food and care, and (2) a strong constitution, which will enable the fowls to digest and assimilate a large amount of food; in other words, fowls so strong physicially that they will stand forcing for egg production. In this relation, we may look at the fowl as a machine. If that machine is so strong that it can be run at its full capacity all the time, much greater profit will be derived than if it can be run at its full capacity only a part of the time.

There is, perhaps, no time in the history of the fowl that will indicate its vigor so well as the molting period. Fowls that molt in a very short time and hardly stop laying during this period, as a rule, have strong, vigorous constitutions, and if properly fed give a large yearly record. On the other hand, those that are a long time molting have not the vigor and strength to digest and assimilate food enough to produce the requisite number of eggs. If it is necessary to select fowls at sometime during the year other than the molting period, some indication of their egg-producing power is shown in their general conformation. In selecting a hen for egg production, her form will give some indication of value. A long, deep-bodied fowl is to be chosen rather than one with a short body, whose underline is not unlike a half circle. A strong, hearty, vigorous fowl usually has a long body, a deep chest, with a long and quite straight underline. Other things being equal, the larger bodied fowls of the egg breeds are to be preferred. It is a rule that fowls bred for egg production are larger bodied than those bred for fancy points. Whenever vigor and constitution form an important part in the selection of fowls for breeding, the size of the fowls is invariably increased.

## FEEDING.

In feeding for egg production, a valuable lesson may be learned from nature. It will be observed that our domestic fowls that receive the least care and attention, or, in other words, whose conditions approach more nearly the natural conditions, lay most of their eggs in the springtime. It is our duty, then, as feeders, to note the conditions surrounding these fowls at that time. The weather is warm, they have an abundance of green food, more or less grain, many insects, and plenty of exercise and fresh air. Then, if we are to feed for egg production, we will endeavor to make it springtime all the year round; not only to provide a warm place for our fowls and give them a proper proportion of green food, grain, and meat, but also to provide pure air and plenty of exercise.

Farmers who keep only a small flock of hens, chiefly to provide for the family, frequently make a mistake in feeding too much It has been clearly proven by experiment that corn should not f very large proportion of the grain ration for laying hens; it is t tening, especially for hens kept in close confinement. Until th few years, corn has been considered the universal poultry fo America. This, no doubt, has been largely brought about by its c ness and wide distribution. The recent low prices of wheat hav farmers to feed more of this grain than formerly, and with a c quent improvement in the poultry ration.

When comfortable quarters are provided for the fowls, the nut ratio of the food should be about 1:4; that is, one part of prot muscle-producing compounds to four parts of carbohydrates or and fat-producing compounds. Wheat is to be preferred to corn. make an excellent food, and perhaps come nearer the ideal than any other single grain, particularly if the hull can be removed.

Buckwheat, like wheat, has too wide a nutritive ratio if fed alon produces a white flesh and light-colored yolk if fed in very large tities. In forcing fowls for egg production, as in forcing animal large yields of milk, it is found best to make up a ration of many of grain. This invariably gives better results than one or two of grain, although the nutritive ratio of the ration may be abou same. It has been found by experiment that the fowls not only their ration more when composed of many kinds of grain, but th somewhat larger percentage of the whole ration is digested than it is composed of fewer ingredients. It has been clearly prove experiment that food consumed by the fowls influences the flav the eggs; that in extreme cases not only is the flavor of the foo parted to the eggs, but also the odor. This of itself is sufficient re for always supplying wholesome food for the fowls and seeing to it none but wholesome food is consumed.

It is conceded by the majority of poultrymen that ground or food should form a part of the daily ration. As the digestive org contain the least amount of food in the morning, it is desirable to the soft food at this time, for the reason that it will be digested assimilated quicker than whole grain. A mixture of equal parts weight, of corn and oats ground, added to an equal weight of w bran and fine middlings, makes a good morning food if mixed with or water, thoroughly wet without being sloppy. If the mixtu inclined to be sticky the proportion of bran should be increased little linseed meal will improve the mixture, particularly for hens ing the molting period, or for chickens when they are growing feath If prepared meat scrap or animal meal is to be fed it should be with this soft food in proportion of about 1 pound to 25 hens. It be necessary to feed this food in troughs to avoid soiling before consumed.

The grain ration should consist largely of whole wheat, some oats, and perhaps a little cracked corn. This should be scattered in the litter which should always cover the floor of the poultry house. It is necessary to have the floor of the poultry house covered with a litter of some kind to insure cleanliness. Straw, chaff, buckwheat hulls, cut cornstalks, all make excellent litters. The object of scattering the grain in this litter is to give the fowls exercise. All breeds of fowls that are noted for egg production are active, nervous, and like to be continually at work. How to keep them busy is a problem not easily solved. Feeding the grain as described will go a long way toward providing exercise. If the fowls are fed three times a day they should not be fed all they will eat at noon. Make them find every kernel. At night, just before going on the perches, they should have all they will eat up clean. At no time should mature fowls be fed more than they can eat. Keep them always active, always on the lookout for another kernel of grain.

### GREEN FOOD.

While perhaps not strictly necessary for their existence, some kind of green food is necessary for the greatest production of eggs. Where fowls are kept in pens and yards throughout the year, it is always best to supply some green food. The question how to supply the best food most cheaply is one that each individual must solve largely for himself. In a general way, however, it may be said that during the winter and early spring months, mangel-wurzels, if properly kept, may be fed to good advantage. The fowls relish them, and they are easily prepared. As it is not difficult to grow from 10 to 20 tons of these roots per acre, their cost is not excessive. In feeding these beets to flocks of hens, a very good practice is simply to split the root lengthwise with a large knife. The fowls will then be able to pick out all of the crisp, fresh food from the exposed cut surface. These large pieces have the advantage over smaller pieces in this respect: The smaller pieces when fed from troughs or dishes, will be thrown into the litter and soiled more or less before being consumed by the fowls, and, in fact, many pieces will become so dirty that they will not, nor should they, be eaten. Large pieces can not be thrown about, and remain clean and fresh until wholly consumed.

Clover, during the early spring, is perhaps one of the cheapest and best foods. It is readily eaten when cut fine in a fodder cutter, and furnishes a considerable amount of nitrogen. If clover is frequently mowed, fresh food of this kind may be obtained nearly all summer, particularly if the season be a wet one. Should the supply of clover be limited or the season unusually dry, green food may be cheaply and easily grown in the form of Dwarf Essex rape. This should be sown in drills and given the same cultivation as corn or potatoes. When the rape is from 8 inches to a foot in height, it may be cut and fed. It furnishes a fresh, crisp food that is readily eaten. If cut a few inches from the ground, a second and sometimes a third crop will be produced from one seeding. Alfalfa will also furnish an abundance of green food. It must, however, be cut frequently, each cutting being made before the stalks become hard or woody.

A good quality of clover hay cut fine and steamed makes an excellent food for laying hens if mixed with the soft food.

Cabbages can be grown cheaply in many localities and make excellent green food so long as they can be kept fresh and crisp. Kale and beet leaves are equally as good and are readily eaten. Sweet apples are also suitable, and, in fact, almost any crisp, fresh, green food can be fed with profit. The green food, in many instances, may be cut fine and fed with the soft food, but, as a rule, it is better to feed separately during the middle of the day, in such quantities that the fowls have about all they can eat at one time.

### GRIT.

It is necessary that fowls have access to some kind of grit if grain food is fed in any considerable quantities. During the summer months, when they have free access to the yards or runs, it will not be necessary to provide grit, providing the soil is at all gravelly. If, on the other hand, the soil is fine sand or clay, it will be necessary not only to provide grit during the winter months, but throughout the whole year.

Small pieces of crushed stone, flint, or crockery ware will answer the purpose admirably. There are many poultry supply houses which keep constantly on hand crushed granite in various sizes suitable for nearly all kinds of domesticated fowls.

Crushed oyster shells, to a large extent, will supply the necessary material for grinding their food and at the same time furnish lime for the egg shells. Chemical analysis and experiments, together with the reports from many practical poultrymen, show conclusively that the ordinary grain and the green food supplied to laying hens do not contain enough lime for the formation of the egg shells. It will require several times as much lime as is ordinarily fed if good, strong egg shells are to be produced. Crushed oyster shells will supply this necessary lime if kept continually before the fowls, trusting to them to eat the amount needed to supply lime rather than mixing the shells with food. The judgment of the fowl can be relied upon in this respect.

### MEAT FOOD.

Where fowls are kept in confinement it will be necessary to supply some meat food. Finely cut fresh bone from the meat markets is one of the best if not the best kind of meat food for laying hens and young chickens. Unfortunately, it is not practicable for many poultrymen to depend wholly on this product, for the reason that it is often inconvenient or impossible to obtain, and when once secured it can not be kept in warm weather without becoming tainted. Tainted bones should be rejected as unfit for food. Skim milk may be substituted wholly or in part for meat food without a decrease in egg production provided the the proper grain ration is given.

### FEEDING SMALL CHICKENS.

Chickens do not require food for the first twelve to thirty-six hours after hatching. One of the best foods that can be fed the first few days is stale bread soaked in milk. This should be crumbled fine and placed where the chickens have free access to it, and where they can not step on it. One of the difficult problems for the amateur poultryman is to devise some means for feeding little chickens so that they can consume all of the food without soiling it. If placed on the floor of the brooder or the brooder run, the larger part of the food will be trampled upon and will soon become unfit to eat.

A simple and efficient feeding trough may be made by tacking a piece of tin about 3½ inches wide along the edge of a half-inch board so that the tin projects about an inch and a half on either side of the board, bending the tin so as to form a shallow trough, and fastening the board to blocks which raise it from 1 to 2 inches from the floor. (See fig. 4.) The trough may be from 1 to 3 feet long. It is within easy reach of the chickens and so narrow that they can not stand upon the edges. Food placed in such feeding troughs can be kept clean until wholly consumed.

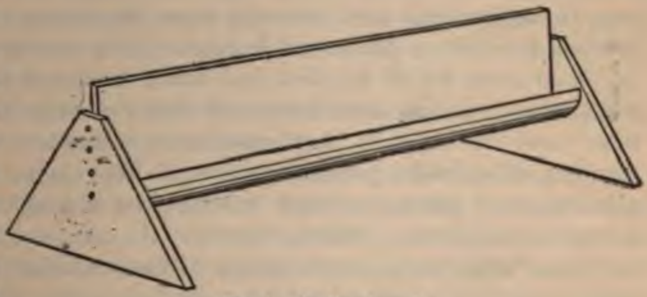

FIG. 4.—Feeding trough.

Granulated oats (with the hulls removed) make an excellent food for young chickens. There is, perhaps, no better grain food for young chickens than oats prepared in this manner. It may be fed to good advantage after the second or third day in connection with the bread sopped in milk. A good practice is to keep it before them all the time.

The chickens should have free access to some kind of grit after the first day. Coarse sand makes an excellent grit for very young chickens. As they get a little older some coarser material must be provided.

Milk is an excellent food for these young fowls, but requires skill in feeding.

One of the great difficulties in rearing fowls is to carry young chickens through the first two weeks without bowel disorders. Too low temperature in the brooder, improper food and injudicious feeding, even if the right kinds of food are given, each plays an important part in producing these disorders. After the first ten days milk may b more freely, perhaps, than during the earlier stages of the chick ence. As the chick becomes a little older, more uncooked food fed. A mixture of fine middlings, wheat bran, a little corn meal little linseed meal mixed with milk makes a valuable food. Hard eggs may be fed from the beginning, but, like milk, require mo than the feeding of bread sopped in milk. On farms where scr from the various grains become really a by-product, these form and efficient food for the little chickens. Wheat screenings, esp form one of the best foods, particularly if they contain a consi portion of good kernels that have been cracked in thrashing. too, the screenings contain a number of weed seeds that have so ing value and are relished by the fowls. They not only provid nance, but give variety, and this, in a measure, improves the health.

Drinking fountains require close attention. Small chicken frequently and oftentimes with their beaks loaded with food, left, to a greater or less extent, in the water supply. As it is nece keep these fountains in a tolerably warm atmosphere, they soon tainted and emit a disagreeable odor. This condition must n lowed to exist, for all the food and drink consumed by fowls sh wholesome. It has often been said that "cleanliness is next ness," and certain it is that cleanliness is next to success in keeping. The drinking fountains must be kept clean. If automat tains are used great care must be exercised in keeping them cl free from bad odors. Nothing less than frequent scalding with hot water will answer the purpose. A cheap, efficient drinking may be made of a tin can with a small hole in one end near the the can, under which is soldered a crescent-shaped piece of tin ing a lip or a small receptacle for water. If the can is filled with and then placed on its side, a small quantity of water will ru the opening and remain in this crescent-shaped lip. As the drink this water a quantity of air will pass into the opening little more water will flow out. This kind of fountain will keep the chickens a small quantity of water at all times accessib exercising care and keeping the fountain thoroughly clean, satis results are easily obtained from this arrangement.

## BROODERS.

If one resorts to artificial incubation it will be necessary to pr brooder of some kind. It may be simple and quite inexpen complex and costly. It is not necessary to expend very much m the construction of an efficient brooder. It is necessary, how see that the brooder is capable of doing certain things. Some of requisites are summed up in the following: It must be warm.

the chickens require a temperature of from 90° to 100° the first few days, and at all times they should find it so warm in the brooder that they are not inclined to huddle together to keep warm. If the brooder is automatic, then the temperature may be kept quite even throughout the whole floor space. If, on the other hand, the brooder is heated from one side or from the top, and is not automatic, it will be best to construct it so that certain parts of the machine will be very warm, in fact, a little warmer than is necessary for the chickens, and some other part somewhat too cool. It does not take them long to learn just where the most comfortable position is. They may be trusted entirely to select the proper temperature if the brooder is of sufficient size so that it is never crowded. A brooder constructed on this plan will require less attention than almost any other. It may undergo a considerable variation in temperature without overheating or chilling the chickens.

The brooder should be easily cleaned and so constructed that all of the floor space can readily be seen. Inconvenient corners are objectionable in brooders, in fact, any corner is objectionable, but if brooders are constructed cheaply, it is almost necessary to make more or less corners. If constructed of wood, circular ones are somewhat more expensive than square or rectangular ones. The floor must not only be kept clean but dry.

Top or side heat is to be preferred to bottom heat, but there must be sufficient bottom heat to keep the floor dry.

As the chickens get a few days old, plenty of exercise must be provided. One objection to many of the brooders in the market is that the chickens are kept too closely confined and not allowed sufficient exercise. It will be a matter of surprise to many to learn how much exercise these little fellows require. With the young chicken, as with the athlete, strength is acquired by exercise, and above all other conditions of growth, strength is the one thing necessary in the young chicken.

## INCUBATORS.

The modern improvement in incubators has made the rearing of fowls solely for egg production quite out of the question unless these machines are used. No experienced poultryman at the present time will undertake to rear fowls in large numbers for the production of eggs and depend on the hens that lay the eggs for incubation. The Mediterranean fowls can not be depended upon for natural incubation. Artificial incubation must be resorted to if these fowls are to be reared in considerable numbers.

There are many kinds of excellent incubators on the market. As with many kinds of farm machinery, it is impossible to say that one particular kind is better than all others. Then, too, an incubator that would give very satisfactory results with one individual might prove to be quite inferior in the hands of another person. What is best for one is not necessarily best for another. It is advisable, before investing extensively in any make of incubator, to thoroughly understand the machine. If good results are obtained, then additional machines of the same kind should be purchased. Failures are recorded simply because the individual fails to thoroughly understand the machine he is trying to operate, or, in other words, fails to learn how to operate that particular machine to the best advantage. A successful poultryman must necessarily pay close attention to petty details. Not only is this necessary in caring for little chickens and mature fowls, but also in the care and management of incubators and brooders. The whole business is one of details. While incubators may vary considerably one from another, yet there are certain points to which all should conform. Some of these points are summed up in the following:

(1) They should be well made of well-seasoned lumber. The effort of manufacturers to meet a popular demand for cheap machines has placed on the market incubators that are not only cheaply made, but made of cheap and not thoroughly seasoned material.

(2) The incubator should be easy of operation. All its adjustments should be easily made and so arranged that the more delicate machinery is in plain view of the operator. The machine should be automatic in operation. When supplied with the necessary heat it should control perfectly within certain limits the temperature of the egg chamber. This result is accomplished in various ways. The regulating force, whatever it may be, should be placed within the egg chamber so that the regulator may vary as the temperature in the egg chamber varies, irrespective of the changes of temperature of the room in which the incubator is placed. The regulator must be sensitive. The change of temperature which is necessary for the complete working of the regulator ought not to be more than 1 degree; that is, 1 degree above or below the desired temperature. It is better if the range of temperature can be reduced to one-half of 1 degree, thus making a total variation of 1 degree instead of 2 degrees.

It should not be inferred that a much wider variation than this will not give excellent results under otherwise favorable conditions, but, other things being equal, those machines which are most nearly automatic are to be preferred.

In addition to the foregoing requisites, a convenient appliance for turning the eggs, positive in its action, should accompany each incubator. This may be an extra tray that is to be placed bottom side up over the tray of eggs and held firmly in this position while both trays are turned, thus completely transferring the eggs from one tray to another without jar. The different machines have very different appliances for accomplishing this result. Excellent results are obtained by the use of many machines now on the market when the operator of these various machines is thoroughly interested. Poultrymen have, for a term of years, hatched in incubators over 80 per cent of all eggs put the machine. It must not be inferred that this is an easy thing to do. A record of this kind is attained only by close observation and good judgment, not only in running the machine, but also in the breeding and care of the fowls to produce fertile eggs.

### DISEASE AND LICE.

Disease and lice are the great obstacles to be overcome in poultry raising. The houses may be kept free from lice by a liberal use of kerosene emulsion and by whitewashing. Whitewash serves a double purpose, that of ridding the house of lice and making the interior much lighter. A small window, with the interior of the house whitewashed, will make the building as light as a much larger window without the whitewash. If the poultry houses are kept free from lice, the fowls can usually be depended upon to keep themselves free by a liberal use of the dust bath. If, however, body lice are found, they may be successfully treated by dusting insect powder under the feathers in the evening and allowing the fowls to remain undisturbed on the perches after the treatment.

*Gapes* in chickens frequently destroy large numbers, and are caused by trematode worms in the windpipe. The number of worms is sometimes so great as to completely choke the fowl. A feather moistened with turpentine or kerosene oil and inserted into the windpipe and turned until the worms are removed is a practice quite largely recommended. Others recommend removing the worms with a fine wire or horsehair, doubled so as to form a loup; this is to be inserted into the windpipe and turned until the worms are detached, and then withdrawn, bringing the worms with it. Another remedy practiced by some poultrymen is to cause the chickens to breathe air in a confined space into which fine, slaked lime is occasionally dusted.

Preventive measures are far more satisfactory than the treatment of infected fowls. The pens and yards should be kept clean and dry and the chickens kept in as thrifty condition as possible by supplying proper food and exercise. While these conditions may not insure absolute freedom from the disease in every instance, yet to moisture and filth can be attributed nearly all cases of gapes, particularly if the yards or pens were previously occupied by infected birds. Yards that have been allowed to become damp, filthy, and infected with the gapeworm may be improved by draining and thorough cultivation. Heavy applications of lime just before cultivating or saturation of the soil with strong salt solution (provided no crop is to be grown) are recommended by experienced poultrymen.

*Chicken cholera.*—This is an exceedingly fatal contagious disease, which is widely distributed over this country, and causes enormous annual losses, especially in the central and southern sections.

The first symptom of the disease is, in the majority of cases, a yellow coloration of that part of the excrement which is usually white, quickly

followed by violent diarrhea and rise of temperature. Other co
accompanying symptoms are drooping of the wings, stupor, les
appetite, and excessive thirst. Since the disease is due to a sp
germ, it can only be introduced into a flock by direct importation o
germ, generally by fowls from infected premises. As soon as the s
toms of the disease are observed "the fowls should be separat
much as possible and given restricted quarters, where they may b
served and where disinfectants can be freely used. As soon a
peculiar diarrhea is noticed with any of the fowls, the birds of
lot should be changed to fresh ground and the sick ones killed.
infected excrement should be carefully scraped up and burned, an
inclosure in which it has been thoroughly disinfected with a on
per cent solution of sulphuric acid or a 1 per cent solution of ca
acid, which may be applied with an ordinary watering pot. Dead
should be burned or deeply buried at a distance from the ground
quented by the fowls.

"The germs of the disease are taken into the system only b
mouth, and for this reason the watering troughs and feeding p
must be kept thoroughly free from them by frequent disinfection
one of the solutions mentioned. * * *

"Treatment of sick birds is not to be recommended under an
cumstances. The malady runs its course, as a rule, in one, tw
three days, and it can only be checked with great difficulty."[1]

*Roup* is one of the most dreaded of diseases. It is sometimes sp
of as the winter disease. The symptoms are hoarse breathing, sw
eyes, discharge at the nostrils, and sometimes a fetid breath. T
ment is not generally satisfactory. The affected birds shoul
removed, the houses cleansed and disinfected. Damp, foul air and
drafts in the poultry houses should be carefully avoided whenever f
are subject to roup. A decrease in the proportion of corn and
increase in the proportion of meat food in the daily ration is held
some to be highly beneficial in warding off this disease.

In general, the treatment of the common diseases of fowls is no
satisfactory as preventive measures. Nowhere more than in the pou
business does that old adage apply, "An ounce of prevention is wo
a pound of cure."

## DRESSING AND SHIPPING.

A considerable proportion of the dressed poultry consigned to
mission houses in large cities brings to the producer a much sm
profit than it would had the same poultry been dressed and pack
shipment with greater skill. It is of prime importance that the p
products be placed on the market in a condition that will make t
appear as inviting as possible. Proper feeding for two or three w
before the fowls are slaughtered will improve their color mate

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[1] D. E. Salmon, U. S. Dept. Agr., Rpt. 1880, p. 444.

In most of the American markets fat fowls with a yellow skin bring the highest price. This condition may be secured most cheaply by feeding a grain ration composed largely of corn for two or three weeks before the fowls are slaughtered. Of the more common grain foods there is none that excels corn for this purpose.

The commission men and shippers, who study in detail dressing and packing, state that uniformly fine quality will soon acquire a reputation among buyers. The shipper should always be careful to have the product look as neat as possible. In some of the large cities ordinances prohibit the sale of dressed poultry with food in their crops. In a few instances the sale of live poultry in coops which contain food is also prohibited. In all cases it is best to withhold food from twelve to twenty-four hours before killing, but the fowls should have plenty of water during this time, that they may be able to digest and assimilate food already consumed. All fowls should be killed by cutting through the roof of the mouth and allowing them to bleed to death. In all operations of dressing avoid cutting or bruising the skin or breaking bones. Care is required in the case of the heavy fowls in picking and handling to prevent bruising the skin. In packing fowls use neat, clean, and as light packages as will carry safely. Boxes or barrels holding about two hundred pounds meet these requirements best; boxes are better for turkeys and geese and barrels for chickens. Barrels may be used, however, for dry shipment as well as for hot weather shipment when the fowls are to be packed in ice.

In shipping live poultry the coop should be high enough to allow the fowls to stand upright without bending their legs. When large coops are used there should be partitions, so that if the coops are tipped all of the fowls are not thrown to one side. They should have plenty of room in the coop. If possible put only one kind in a coop or in one division of a coop.

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ecretary of Agriculture, Washington, D. C.

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U. S. DEPARTMENT OF AGRICULTURE.

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FARMERS' BULLETIN No. 42.

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# ACTS ABOUT MILK.

(REVISED.)

BY

R. A. PEARSON, M. S.,

*rofessor of Dairy Industry, College of Agriculture, Cornell University.*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

# LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY
*Washington, D. C., February 10,*

SIR: I have the honor to transmit herewith and to recomm
ublication a revision of Farmers' Bulletin No. 42, entitled
bout Milk," by R. A. Pearson, M. S., professor of dairy indu
he College of Agriculture of Cornell University. The origin
etin was prepared ten years ago while the author was assistan
f the Dairy Division of this Bureau. It has had a large circ
nd there is a continuous demand for such information. The
as now been revised and brought up to date by Professor P
nder the direction of the Dairy Division.

Respectfully,
A. D. MELVIN,
*Chief of Bur*

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# FACTS ABOUT MILK.

## THE DAIRY INDUSTRY.

The production and distribution of milk and milk products engage the attention of no small part of our population. The use of milk is general and not limited to any class or locality; it is regarded as a necessity by almost every family and for this reason information regarding it is important. In the northern and eastern sections of the United States dairying is carried on very extensively; in large parts of these sections it is the chief occupation of the farmers. In the South and West the number of cows is rapidly increasing. This branch of agriculture is so widely practiced here that the United States is regarded as the leading dairy country of the world. In 1899 the annual value of our dairy products was estimated to exceed $600,000,000, and the value of the milch cows in the same year was over $500,000,000.

It would be impossible to closely estimate the value of all property devoted to dairying, but it can be safely said that in gross investment it is exceeded by few other branches of industry.[a] There are about 19,000,000 cows in this country, or about one to every four inhabitants; one cow, however, furnishes the milk, butter, and cheese for more than four persons, as some dairy products are exported. Although this is the greatest dairy country in the world, it does not lead in the per capita consumption of dairy products; one of the principal reasons for this is the failure of Americans to appreciate the food value of milk and its products. In some of the older European countries two or three times as much milk and cheese is consumed per capita as in the United States.

The average milk consumption is high in many parts of this country, and, owing to improved methods of production and transportation, it seems to be increasing. It is estimated that the milk from 5,000,000 cows is annually consumed, as milk, in the United States, the average being about 27½ gallons per year to each person; this means 0.6 pint, or a good-sized tumblerful, each day. Many use a much greater quantity, and consequently the number of those who use little or none must

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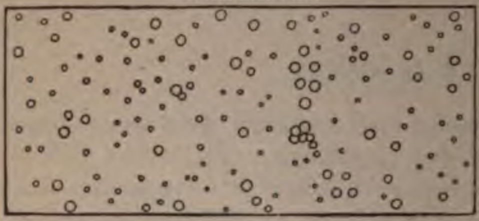
[a] For the statistics of dairying in the United States, see Bulletin No. 55 of the Bureau of Animal Industry, Department of Agriculture.

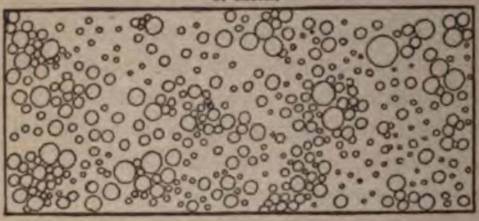
be very large in order to make this average. Within
cream has become an important article of commerce,
localities condensed milk is extensively used.

The value of these foods is often much diminished or
because of lack of information on the part of the pur
the producer and dealer as well—regarding the peculiar
dairy products
methods of keepi
them.

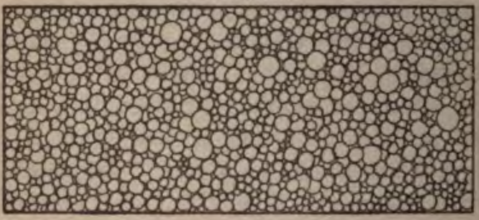
a. Skimmed milk.



b. Milk.



c. Cream.



d. Colostrum.

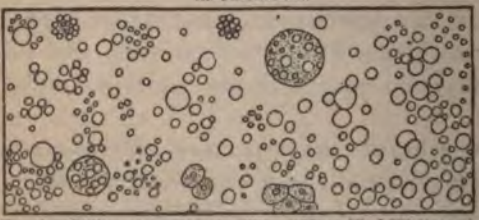


FIG. 1.—Different grades of milk. (Magnified 300 times.)

### MILK

Milk is a whi
liquid. To the
server it appears
fect solution, a
monly regarded
ing bought and s
measure, but whe
der the microsco
to consist of a
parent fluid cont
minute globules
sizes (fig. 1*b*). T
called the milk
sists of water and
constituents of
the fat; and thes
stituents, althou
when separated
mostly all disso
water, but part o
a state of fine s
partial solution.
ules are little bod
fat scattered thr
rum and not dis
are semisolid an
the serum a mixt
emulsion.

### CONSTITUENTS.

The solid constituents present in the serum in largest
sugar and casein. Albumen and mineral matter are pre
quantity, and there is also believed to be a little fibrin re
fibrin of blood. In milk there is more sugar than an
component. This milk sugar can be separated from the

ght into solid form; as sold, it resembles powdered white sugar.
used to a considerable extent by druggists, also by manufacturers
rtain proprietary foods, especially those for infants. It is not as
t as cane sugar, but is fully as digestible, if not more so. Its
nercial value is not sufficient to induce its manufacture in large
tities. Sugar is the constituent of milk which undergoes the
est change when milk sours. Casein and albumen of milk are
hief nitrogenous constituents, and are generally referred to as
ding all of this class of substances in milk. They belong to the
ral class of foods which includes the lean meats and white of egg.
or rennet causes casein to coagulate, forming curd, and as such
ne of the chief ingredients of cheese, constituting about one-fourth
at important food. The albumen may be coagulated by heat.
mineral matter in milk, called ash or salts, is the part that remains
milk is evaporated to dryness and burned; this consists chiefly
osphates and chlorides of soda, potash, and lime.

is well known that when sugar is dissolved in water the solution
s limpid than pure water, and if many small bodies a very little
er than water were thoroughly mixed into the solution their rise
d be more or less retarded by the stickiness of the surrounding
. Milk might be compared to a thin sirup with many fatty and
particles floating in it, as just described. It is viscous or sticky,
se of the solids held in solution and suspension; and this viscosity,
her with fibrin, has a considerable effect in retarding the rise of
at globules and the formation of the cream layer. The older milk
e more effective are these forces. The fat globules are so small
single drop contains many millions of them. It is said that if
son should attempt to count the globules in a drop of milk it
l take ten years of his time, provided he counted at the rate of
er minute and worked ten hours per day six days every week.
a number is too large to be appreciated. The globules average
one ten-thousandth of an inch in diameter, and twenty-five of
ge size placed side by side would about represent the thickness
linary writing paper. Globules of different sizes are found in
nilk of any cow, but with certain breeds the sizes average
than with other breeds. The milk of Jersey and Guernsey cows
is peculiarity, which explains why the cream rises so readily on
why the skimmed milk is so thin and poor, large globules nat-
being able to get to the top more quickly than small ones, many
ich can not rise at all.

## COMPOSITION.

hundred pounds of average milk contains about the following
nts of the different constituents: 87 pounds of water, 4 pounds of
pounds of milk sugar, 3.3 pounds of casein and albumen, and 0.7

pound of mineral matter or salts. These proportions are g
shown in the accompanying illustration (fig. 2).

But the quantities of the constituents vary between wide lin
total solids of milk, meaning all the constituents except wat
as low as 10 or as high as 18 parts in 100. This variatio
several causes, some of which are given later. The fat vari
tity more than any other part of the milk, running as low a
parts in 100 and as high as 8; the larger the proportion of fat
the milk is said to be. Most of the States and many cities h
standard for the composition of milk, and any milk falling
standard is legally regarded as adulterated although it may
the natural product. The laws usually require 3 or 3½ p
fat, and 9 or 9½ per cent of "solids not fat." (This term is

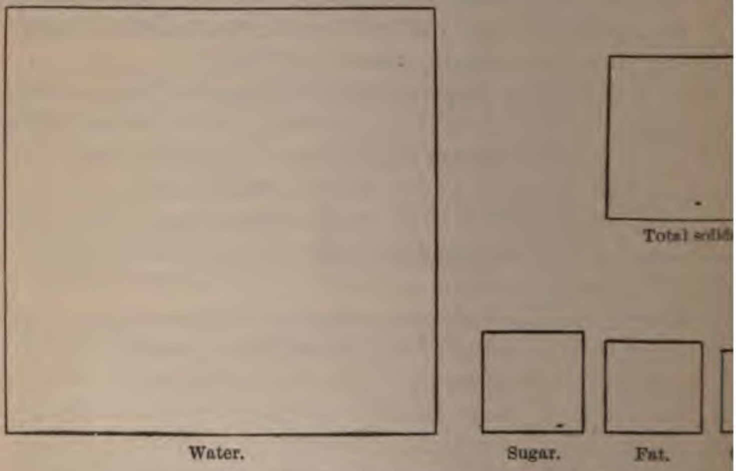


FIG. 2.—Proportions of the component parts of milk.

used to designate all the solid substances of milk other than
total solids required thus vary from 12 to 13 per cent, ac
different laws, which means, of course, that in every 100
milk there shall be 12 or 13 pounds of solid matter. T
requirements are justified by the fact that it is the solid
not the water which gives value to milk.

The fact that the standard so often relates to the proporti
centage of fat and the popular impression that milk is with
after the cream has been removed lead some people to thin
is the only valuable part of milk. This is a great error. T
other constituents are valuable; for example, casein is o
cheapest forms of nitrogenous food and is more nutritious th
compounds in many other foods. It is, of course, safe to
the quality and value of milk by the fat it contains, becaus

is poor from either natural or unnatural causes, the quantity of fat will be affected at least as much and oftentimes more than any other constituent.

## CAUSES OF DIFFERENCES IN THE COMPOSITION OF MILK.

The composition of milk depends largely upon the kind of cows producing it. Jerseys and Guernseys, by some people called Alderneys, produce a rich milk, in which most of the fat rises and forms the cream layer quickly. It has been explained that this is because the fat globules are relatively large. This is a decided advantage to those who wish to raise cream, but not if the milk is to be used whole. It may be a positive disadvantage, in some cases, to have the cream separate too soon. Durham and Ayrshire cows give milk of an average quality from which the cream rises slowly, and on this account they are sometimes said to be good "milkman's cows." Holstein milk usually has a small proportion of fat or cream, but some families of these "black and whites" supply a product of excellent quality. The Holstein cows are noted for producing enormous quantities of milk.

Although these statements refer to pure-bred cows of the different breeds named, they also apply to grade animals having one-half or more of the blood of these breeds. But in either case, especially the latter, there are many exceptions to the rule. All cows of the same breed do not give milk of the same quality; in fact, the composition of milk from individual cows of the same breed sometimes varies as much as that from cows of different breeds. It is a popular notion that the feed given a cow influences the quality of her milk more than anything else; but if a cow in normal condition gives a rich milk at one period, her milk will be of good quality at all times, unless she is badly neglected or diseased. Feed has a much greater influence upon the quantity of milk produced than upon its quality.

The first milk given after calving is called colostrum (fig. 1, *d*). It contains a large proportion of albuminoids and is somewhat laxative. It is not fit for food, except for the newly born. In natural milk a small amount of albumen is present, but in colostrum the albumen often exceeds the amount of casein, and these two constituents may form over 15 per cent of the milk. The percentage of sugar in colostrum is usually low; the fat is usually about normal, though it may be in excess or deficient. The composition of colostrum changes rapidly, and within a few days after birth of the calf natural milk is given. After this the percentage of fat in the milk from any cow varies more or less from day to day, even if her feed, care, and general treatment are always alike. The causes of the sudden changes are not always known; in fact, the fat often seems to increase or decrease without any cause. Sometimes the fat content changes as much as one-third within twenty-four hours. As the period of lactation progresses there is a tendency to a gradual increase of the total solids and the physical condition of the milk is so altered that cream rises less easily.

In well-regulated dairies each cow is milked about ten months of the year; the remainder of the year she is said to be "dry." Where a dairyman takes the product of his herd to a cheese factory it is the custom to have all the cows give milk in the summer time and none in winter, but where he supplies milk for retail customers he endeavors to have only a small part of the herd dry at one time, so there will be always enough cows in milk to supply his trade. An incidental advantage of this is that the milk from fresh cows is added to that from cows more advanced in the milking period, and the changes due to the time of lactation are avoided in the mixed milk, which is thus kept of uniform quality.

## DIFFICULTIES IN OBTAINING PURE MILK.

The first thing to be borne in mind is that milk is naturally a pure product. If any milk is found unclean, unwholesome, or disproportioned in its proper parts, the chances are that it is not the fault of the cow. In all such cases the presumption is that some person is to blame, either the one who cares for the cow or the one who handles the milk. If those who buy milk used proper care they would have little trouble in always procuring a good clean article. It is possible to produce milk free from harmful contamination, and if impure milk is delivered the dairyman or dealer may be held responsible, and it is the duty of the customer to reject it. When the milkman knows that his customers will not accept poor or unclean milk, he will stop offering it.

On the other hand, some people are most unreasonable in their complaints and demands upon their milkmen. This and the sharp competition between rival dealers are two chief causes of dishonesty in the milk business. When a milk peddler knows that he is delivering the best of milk and complaint is made that it is not yellow enough or has not enough "body," and he is afraid of losing a good customer, he is naturally tempted either to give that person a supply from near the top of a can, thus depriving some one else of cream which rightly belongs to him, or to do what he thinks his dishonest competitor is doing, whatever that may be. There is a great desire on the part of purchasers to get milk cheap, and it is not an unknown thing for customers, including hotels and private institutions as well as private families, to demand such large measure for their money that the dealers feel compelled to "extend" the milk in order to meet these requirements and prevent loss of trade. Some are satisfied with the adulterated stuff, not knowing that the same amount of actual food, but no more and perhaps less, is being delivered in the large measure than was formerly delivered in the smaller one. This explains how it sometimes happens that milk is retailed in cities at less than the regular wholesale price. People too easily forget quality and think only of quantity. The only sensible thing for the housekeeper or other buyer of milk to do is willingly to pay a fair price and insist upon good milk in return. Buyers should remember that at the highest prices usual anywhere good milk is one of the cheapest articles of food that can be purchased.

It should also be borne in mind that milk can be contaminated as easily after delivery to the consumer as before, and too often a milkman is blamed for bad milk or cream when it was made so by conditions over which he had no control. If left where dust can settle in it or flies have access to it, or if set in an illy ventilated cellar, in a warm place, or where it can absorb odors, it is pretty certain to be in bad condition after a few hours, no matter how good it was when delivered.

Numerous well-authenticated cases are known where customers have complained of milk received, and upon investigation it has been proved that servants in the house tampered with the milk, removing cream for their own use or adding old milk or vinegar to make it sour prematurely. The object of the latter act was, in connivance with an outsider who supplied the motive, to cause the buyer to change to some other dealer whom the servant was ready to recommend.

Attention on the part of consumers to the proper way of producing and handling milk would result in a great improvement of this most important food. Laws may do much to prevent fraud, but customers who know exactly what they want, how to get it and how to care for it, have a much greater effect on milk producers and dealers than any possible laws.

## CHANGES IN MILK.

Pure as milk may be in its natural state, it is a perishable product, and although with a proper knowledge of its peculiarities and care in its keeping it can be held in a wholesome state a reasonable length of time, there are natural changes which are sure to occur as soon as opportunity is given. Thunderstorms, impurities, warm temperature, and other conditions known to exist when milk is most liable to give trouble have been blamed for its changes. But it is now known that these are only indirect causes, and that the changes in milk which bother the housekeeper are due to and can not take place without the presence of minute organisms called bacteria. The souring of milk and other changes or fermentations have been discussed in Farmers' Bulletin No. 29, issued by the Department of Agriculture. That bulletin describes the bacteria and various fermentations of milk, including the common changes and those which cause it to become blue, bitter, slimy, or ropy, and treats of the practical bearing of the subject upon dairying.

Any milk showing a sediment is suspicious. Particles of dirt are a sign that germs are abundant. Thus dirty milk may be dangerous as well as disgusting. The dirt in milk consists mostly of particles of dust, dead skin, manure, and hairs which fall into the pail from the body of the cow during milking; but dust in the stable, dirt and dust in the vessels used for handling milk, and unclean attendants are also common sources of dirty sediment in milk.

Milk from unhealthy or unthrifty cows or that which has been handled by sick persons is dangerous, as it may contain infectious germs or foreign substances which might affect the health of the consumer. Typhoid fever, scarlet fever, diphtheria, and consumption (or tuberculosis) have been spread by milk. Feverish cows, those having just given birth to a calf, and sometimes cows that have been milked a long time, produce milk which should not be used. Any milk having an unnatural appearance should be discarded.

Odors and peculiar flavors are due to bacterial action or to the volatile oils of some foods; onions, turnips, cabbage, and certain weeds, as garlic and wormwood, give characteristic odors and tastes to milk. When odors or flavors are most marked at the time milk is first drawn, they are generally due to food eaten by the cow. When they are slight at first and gradually increase as the milk becomes older, they are generally due to the growth of bacteria.

## ADULTERATION.

The most common forms of fraud practiced with milk are the removal of a part of the cream and the addition of water. Color is sometimes added, but the addition of chalk, burnt sugar, salt, or other substances, although often charged, is in fact quite rare. The mixing or blending of milk means the mixing of good milk with poor milk to obtain an average quality. Sometimes skimmed milk is mixed with a lot of good quality to make a medium grade; this practice amounts to exactly the same as removing a part of the cream. Most communities have laws against adulteration, but they are not always rigidly enforced. Adulterated milk is objectionable in proportion as it contains less food value than represented, and the consumer is deprived of nourishment which is supposed to be given. But this is not the worst about milk that has been adulterated by water. If a dairyman is dishonest enough to water his milk he will probably not be careful about the purity of the water added. Impure water contains many bacteria. Most of them are harmless, but in an immense number there are likely to be some dangerous species, such as disease germs and bacteria producing changes in milk which cause diarrheal disturbances. Epidemics of contagious diseases have been traced directly to contaminated water added to milk for the purpose of adulteration, or which had been used to rinse the cans.

## PRESERVATIVES.

Various chemicals are sometimes added to milk to prevent its souring, but there are strong objections to them. The most common of these substances contain salicylic acid, boric acid, borax, or formaldehyde. They are not regarded as poisons, but when taken regularly in small doses in milk they may have an injurious effect on the system. They, or mixtures of which they form a large part, are sold under many different names, and are sometimes used also in canned fruits and vegetables. Boric, or boracic, acid is more powerful in its physiological action than borax; both are strong antiseptics. Salicylic acid is a white crystalline powder that is odorless and tasteless. It was once used so extensively in France that fears were entertained lest it would have a detrimental effect on the public health, and a commission was appointed to investigate its action. Their report stated: "The addition of salicylic acid or its derivatives, even in the most minute amounts, to foods, solid or liquid, should not be authorized." The United States Dispensatory says: "Salicylic acid has been used for the preservation of various articles of food, but the employment of it should be interdicted." Formaldehyde is a powerful germicide, which has been shown to have an adverse effect on the digestibility of casein. Public opinion is now strongly against the use of these substances, and the laws of numerous States and cities prohibit them. Small continued doses of preservatives may not affect many people, but may harm others, and no one can tell who might have an idiosyncrasy toward them. Salicylic acid and its salts are eliminated by the kidneys, and as these organs become less active in the aged they feel the effects more than the young. It is easily seen that in the same way in which preservatives prevent the natural changes of milk they may prevent its digestion in the alimentary tract, the process of digestion being similar in many respects to the familiar fermentations. The danger from the use of preservatives would be much less if they were handled only by intelligent persons; a very small amount is sufficient to prevent milk or cream from souring, but an ignorant person is likely to think that if a little is good, more would be better, and so use much more than necessary. Another objection to chemical preservatives is that one accustomed to their use may get in the habit of depending on them so much that he would use even less care with the preserved milk than if it were not preserved.

## CARE OF MILK AFTER DELIVERY.

The proper care of milk after it has been delivered to the
is a matter of great importance. It is desirable to have it i
possible condition for use, and it is not desirable to blame the
for things for which he is not in the least responsible. If mi
in an open vessel in a refrigerator with meats an
kinds of vegetables, it will absorb odors from th
also sensitive to flavors, and if allowed to stand
tin vessel the "tin taste" can be easily recogniz
should therefore be kept in a cool place, free fr
and in a perfectly clean vessel of suitable mat
well-glazed earthen or porcelain dish, or a glass j
tle, is the best container; tin is good so long as it is b
the iron is well covered. Wooden dishes are objec

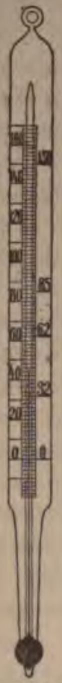


FIG. 3.—Dairy thermometer.

As already stated, the change to which milk is m
is simple souring. The best agent to prevent this
cold or heat. There should be no trouble in keep
sweet at a temperature of 50° F. from twenty-four
six hours after it is in the hands of the custom
can be done if it is delivered in good condition and
handled after delivery. It is the custom in some
leave the milk in open vessels on the doorstep ea
morning, and it often remains there exposed to he
insects, and small animals until wanted in the hous
is a dangerous practice. In hot weather milk ex
this way for any length of time ought to sour soo
it does not it is probably due to the presence of
tives. Too much care can not be used in seeing
milk is cold when delivered, and that it is then imn
put into a cool place. If allowed to stand in the warm air, e
few minutes, the time it will keep sweet is shortened.

Sometimes milk does not keep sweet when no cause can b
ered for its souring. This is frequently the case in summer
the trouble is the refrigerator, which may seem cold on accou
great difference between its temperature and that outside, wh
in fact, not cold, and a thermometer may show its temperat
even above 60° F. A floating dairy thermometer (fig. 3) i
venient article to have in the house. It is a closed glass tub
paper scale inside; it can be put into a liquid without injur
upright in the liquid, and is easily cleaned. The temperatu
milk should occasionally be taken when it is removed from
chest and the cause of early souring may be found. A tem
above 50° F. never should be allowed, and it is better to kee
to 45° or 40° F.

## PASTEURIZATION OF MILK.

The practice of pasteurizing milk is being followed by some dealers who find that it greatly reduces the number of complaints they receive on account of sour milk. The treatment consists of heating the milk to a temperature, usually between 140° and 160° F., at which large numbers of bacteria in the milk are killed, and then cooling it to check the growth of others. If sufficient heat were used to kill all the germs the product would be called sterilized milk, and it might be kept in good condition indefinitely. Unfortunately the higher heat renders milk objectionable to most consumers, by changing its taste and appearance, and perhaps slightly reducing its nutritive value.

Special kinds of apparatus are used for pasteurizing milk on a large scale, and those generally preferred by the dealers are called continuous pasteurizers because they do their work continuously. They are arranged so that the milk to be pasteurized flows through the apparatus in an uninterrupted stream, being heated by passing in a thin layer over a metal surface on the opposite side of which is steam or other heating agent, and being cooled in a similar manner in the same apparatus or another close at hand. Care is taken not to allow the temperature to go so high that a disagreeable cooked flavor is produced.

The pasteurization of milk is desirable when the milk contains large numbers of harmful bacteria, and especially when it is thought to contain some pathogenic or disease-producing bacteria.

The importance of doing the work thoroughly can not be overstated. The temperature must be high enough, and must be retained long enough, to kill disease-producing organisms such as those of typhoid fever. Care must be taken to avoid scorching the milk, and it must be thoroughly cooled and protected from contamination after being heated.

Some persons go so far as to advocate the pasteurization of all market milk in plants controlled by the municipalities. But there are objections to the process as well as advantages, and it is doubtful if it should be adopted except where special need exists. An important objection is that some of the worst types of bacteria are not killed by pasteurizing temperatures, and these grow in the pasteurized milk whenever the temperature permits. Furthermore, they grow more rapidly in pasteurized than in raw milk, because the "sour-milk" organisms, which would be antagonistic to them and hold them in check, have been largely destroyed by the heat. Thus it is possible for objectionable and even dangerous changes to take place in pasteurized milk without being apparent, and a consumer may use highly contaminated milk without knowing it until bad effects are caused. He is warned against common souring which takes place in raw milk by the appearance, taste, and smell of the milk. Some of the strongest champions of pasteurization recognize this objection and advise that it be done not more than twenty-four hours before the milk is consumed, so as to avoid the possibility of extensive bacterial changes without accompanying warning signs as described.

The pasteurization of milk in the home is an easy operation, and mothers should know how to do it, as the necessity may arise at any time. Of course it is best to have clean wholesome milk that does not need to be pasteurized, but sometimes this is impossible and the only milk available for the little ones is from unknown sources and is teeming with bacteria. Undoubtedly such milk has cost many young lives. It is estimated that one-third of all children die before they are 3 years old, and one of the leading causes of infant mortality is unwholesome milk. Bad milk can not be made perfect by pasteurization, but the danger from its consumption can be lessened. The Department of Agriculture has issued circulars giving full directions for pasteurizing milk in small quantities. The process is simple and the necessary apparatus is inexpensive.

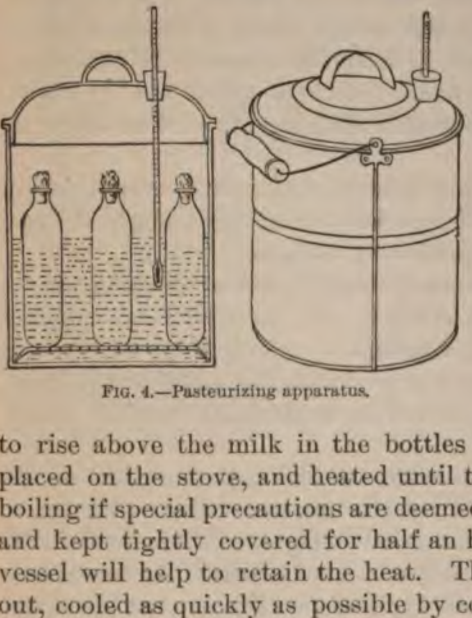


FIG. 4.—Pasteurizing apparatus.

Briefly, the directions are as follows: One or more bottles nearly full of milk are plugged with dry absorbent or other clean cotton and placed in an upright position in a vessel having a false bottom and containing enough water to rise above the milk in the bottles (fig. 4). The vessel is closed, placed on the stove, and heated until the water is 155° F., or even to boiling if special precautions are deemed necessary. It is then removed and kept tightly covered for half an hour. A heavy cloth over the vessel will help to retain the heat. The milk bottles are then taken out, cooled as quickly as possible by cold water or ice, and kept in a cold place. Milk thus prepared may be expected to keep twenty-four hours, and should preferably be used within that time. The cotton plugs should be kept as dry as possible and should not be removed until the milk is to be used. A covered tin pail answers well for the larger vessel. An inverted pie pan with perforated bottom can serve as the false bottom. A hole may be punched in the cover of the pail, a cork inserted, and a chemical thermometer put through the cork so that the bulb dips in the water, thus enabling one to watch the tem- ature closely without removing the cover, or an ordinary dairy *ometer* may be used from time to time by removing the lid.

## CREAM.

hen it is desired to raise cream the milk should be put in a cold , where it will not be disturbed, as soon as possible after it is ved. A good quality of cream for table use can usually be ned in this way. (See fig. 1, *c*.) It will aid the cream in rising if emperature of the milk is raised to about 100° F. and then low- by placing the dish in cold water. This can not be done unless ilk is in good condition, as the high temperature may cause it ur before it will cool sufficiently to prevent souring. Milk jars ttles are now extensively used, and if they are filled when the is fresh, and carefully handled, the cream will show plainly in a few hours, and much less time is required for it to reach the fter it has been delivered than when it has been mixed just ious to delivery. Thus by the use of the jars considerable time ed and fresher cream can be obtained. The jars may be pur- d from any dairy supply company at a small cost, and provide a clean way of handling milk.

parator cream can be made much richer than "gravity" cream, for this reason is preferred for whipping and some other pur- . It may be kept longer, as it can be taken from perfectly fresh , while that raised by gravity is usually 12 to 24 hours old when ned. Cream gradually becomes thicker the longer it is kept, t is often held for this purpose. Sometimes it is 1 or 2 weeks hen used; very little is used in as fresh condition as milk. For eason special care is needed to keep it sweet. Satisfactory results ot obtained by placing it in a refrigerator at a temperature of . It ought to be kept as near the freezing point as possible; it d be placed directly in contact with the ice or, better yet, be ly surrounded with ice. Good efforts will be wasted if the ice up only halfway and the top part is exposed to a warm tempera- —it must be cold throughout. Skimmed milk and buttermilk have the same care as whole milk.

## DETECTING IMPURE MILK.

e of the more common forms of impure milk already have been By pure milk is meant the properly handled product of healthy, d cows. To be legally regarded as pure, in most places, milk ontain at least a certain amount of fat and other solids. It is a t thing to determine by the appearance of milk whether it is pure and even experienced dairymen are frequently unable to do this. slightly yellowish white color, a very slight odor, if any, and have a distinctly sweet and pure taste. When allowed to stand

quietly for several hours, cream should rise naturally, and if
tion is thoroughly effected the cream should form one-eigh
fifth of the total volume or bulk. No sediment should app
bottom of the jar or vessel. When good milk is poured from
it should cling to the glass a little and not run off clean
Skimmed or watered milk is thinner than whole milk and o
shade, being of a bluish-white color. The yellow shade of mil
due to its fat, but as this constituent is more yellow in the mi
cows than others the yellowest milk is not necessarily the ri
it is unsafe to judge by the color alone; poor milk from some
be more highly colored than rich milk from others. Besides
ficial colors are sometimes added by dishonest persons.

When a quantity of milk is to be tested, the first and m
tant thing to be done is to obtain a fair sample—one tha
resent the whole and show its average composition. If t
is taken from near the top or bottom of a vessel of milk
been standing quietly for even a short time, it will be to
too poor in fat. The milk must be well and thoroughly mix
the sample is taken. A good way of doing this is to pour
times from one vessel to another. This should be continue
lumps or collections of cream appear on the surface. If s
ticles of butter are floating about, a fair sample can not
There are several methods of testing milk. A complete ana
chemist will give the exact amount of each component part.
quires considerable time and expense, and is not necessary
tical purposes.

### THE CREAMOMETER.

A very simple test, and one which, although not altogethe
is better than none, is the judgment of milk by the amount o
will show. This is not an accurate test, because it may fail
cream when it should or it may show more than it ought; ho
will not show cream if there is none in the milk. With tw
of milk having the same amount of fat different results ma
with this test, as the proportion of the fat globules which ris
on certain conditions, including the size of the fat globule
age of the milk and the way it was handled before deliver
globules have much difficulty in rising, only a small part of
get to the top and they may carry up with them so much of
constituents that there will be a large bulk of poor cream.
test is carefully conducted and conditions are favorable to t
cream, fair results can usually be obtained. This test requir
graduated glass tube (fig. 5), which is filled with milk to the
and allowed to stand in a cool place for twenty to twenty-fo

may be aided in rising by warming the milk to 100° F. and g it, in the tube, in cold water, or the tube may be filled milk and the remainder with warm water, which raises the e and reduces the viscosity; in such case only half as much appear as the milk is to be given credit for; for example, nts of a glass are half water and show 10 per cent cream ale, this means, of course, 20 per cent of the milk. If the same each day and is tested in the there should be little difference in shown. Tubes graduated specially st are sold by dairy-supply firms. test furnishes a good opportunity sediment; if the milk is not clean, seen in the bottom of the cylinder. d be taken to carry the tube quietly, ther the cream nor the sediment urbed.

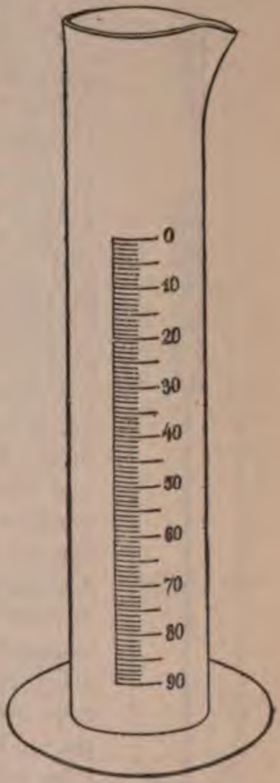


FIG. 5.—Creamometer.

## LACTOMETERS.

little heavier than water. Its spe- y varies from 1.029 to 1.033, which t the weight of pure milk varies to 1.033 times the weight of water. from the standard weight, such as o the quality of the natural milk or g or watering, can be measured by ent called the lactometer. This is l glass bulb with a slender stem raduated scale, and it is so adjusted laced in pure milk it will sink until on the scale is even with the sur- liquid. This point is called the Different kinds of lactometers are in different ways. A style fre- ed and known as the board of health lactometer registers the specific gravity is 1.029, and less than 100 when the avity is less than 1.029. A specific gravity of 1.033 would d by 114 on this lactometer.

venne lactometer is graduated from 15 to 40 and indicates e specific gravity. Thus at 60° F. it would read 32 in milk ecific gravity of 1.032 and it would read 30.5 in milk having ravity of 1.0305. The best forms of lactometers have a er in the stem above the lactometer scale so that the tem-

perature of the milk can be taken at the moment the reading
If the temperature is above or below 60° F. the lactome

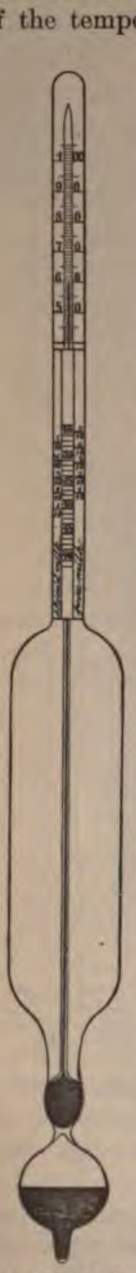


FIG. 6.—Lactometer.

must be corrected, and with the Quevenne
the correction is made by adding 0.1 to the
each degree of temperature above 60° or
0.1 for each degree of temperature below
if the Quevenne lactometer reading is 31 in
a temperature of 56°, the corrected readin
30.6 and the specific gravity at 60°, 1.0306.

Accurate as these instruments are, they
more than show specific gravity. If crea
lighter than milk, is removed, the specific
increased; and if water is added, the spec
is decreased. Therefore if a sample of
high specific gravity, skimming is suspect
it has a low specific gravity, watering is
But if some cream is removed and water
proper proportion, the specific gravity
unchanged; and this is one of the common
all for adulterating milk. If such fraud is
practiced it can be detected by the cream
or, more surely, by the Babcock fat test
on the following page.

A fair opinion of the value of milk, so far
position is concerned, can be formed from t
age of fat, as the total solids of normal mi
and decrease as the amount of fat is great
If milk has been tampered with by waterin
centage of fat is reduced in the same propor
other constituents, but in a greater propo
milk is skimmed. As fat is the part that th
person tries to abstract, the purchaser is on t
if he judges of the quality of the milk by th
it contains. Many tests for the fat of milk
proposed. The lactoscope and other optic
are sometimes used to determine the fat or
they are inaccurate, and especially so in th
one without large experience. Some of th
on the color of the milk or on the fact that
fat there is, the less light will pass through a
But as the color of milk is not an indication
ness, and the same amount of fat will re
light when in small than when in large globules, these me
give incorrect results and are therefore unreliable.

l methods of rapidly determining the fat content of milk with
of chemical reagents have been devised. One of the most
is the Babcock milk test.[a] The little machine constructed to
s test, and of which several patterns are made, is in
most all well-conducted milk-receiving stations. It
about a tablespoonful of milk for a sample, and the
centage of fat in it can be determined by this test in
een minutes. The result is obtained by the action of
al force aided by some chemical agents. The original
he machine is from $4 to $15, according to size and
nd less than 1 cent's worth of materials are used for each
Its manipulation is easily learned, and it can be suc-
operated by any careful person. A definite amount
s[b]) of the milk or cream to be tested is measured in
and placed in a bottle which has a long, slender,
d neck (fig. 7); sulphuric acid is then added, and the
aken until the mixture becomes dark colored, which
but a few moments. The acid does not affect the
it dissolves the other
ids which keep the fat
apart.
ottle is then placed in
ine, by which it is rap-
lved in a horizontal po-
th the neck toward the
The fat is thus forced
the neck by the other
of the bottle, which are
and therefore thrown
om the center to the
f the bottle. Sufficient
ater is added to bring
p into the neck, where
percentage can be read
scale. In the illustra-
pette for measuring the
acid measure, and a test bottle are shown. From two to
four bottles, containing as many different samples, can be tested
, according to the size of the machine. Special bottles of a

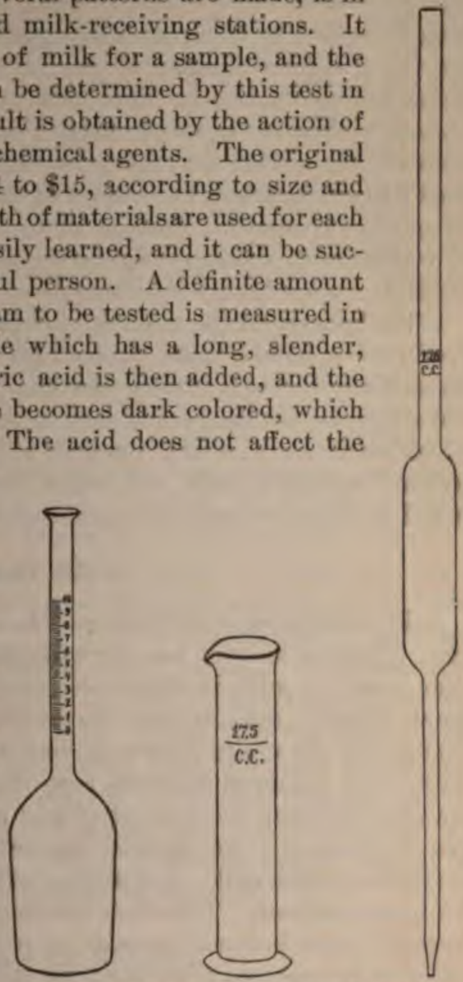


FIG. 7.—Glassware for the Babcock fat test.

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ted by Dr. S. M. Babcock, of the Wisconsin Agricultural Experiment Station,
described in bulletins of that and several other experiment stations.

c. of milk weighs practically 18 grams. Cream is lighter than milk; hence
lume must be taken. For exact results, cream samples should be weighed.

modified form are furnished for testing skimmed milk and cream. ratus for this test is sold by dairy-supply firms. A small machi plete with the necessary glassware and acid, can be obtained f $6. Full directions are sent with the apparatus. These can b followed and quite accurate results obtained after a little prac

A number of other tests which can be quickly and easily ma been described by different investigators. Like the Babcock te are for the determination of the fat only, but are less satis Some testing appliances have been placed on the market necessary chemical agents in bottles designated by a letter or without information as to the character of the liquids. These ha used without sufficient knowledge of their nature, and they ar be unduly expensive. Ether is sent out in this way. This is n as considerable damage might result from an inexperienced handling such a highly inflammable or explosive substance.

If the honesty of the milkman is questioned, it would certai good plan to have a tester on hand for determining fat, and it occasionally be used. Some new test requiring only cheap ap and reagents, not dangerous even in the hands of an ignorant which would show, within one-half of 1 per cent, the correct f tent of a sample of milk, and which could be operated with littl would be most welcome to housekeepers.

### ACID TEST.

Acid commences to form as soon as milk is drawn from the after a certain amount has been developed it becomes evide taste, and the milk is said to be sour. It is sometimes desi know whether milk is near the souring point or not, or if it i enough for the use of a baby or delicate person. It is well kno milk which is almost sour will coagulate on boiling, but this not show whether the amount of acid present is small or great. and Farrington have devised simple methods for determin amount of acid in milk. The method of the latter is the more for household use. Tablets containing a definite quantity of material (such as caustic potash or soda) are dissolved in added to a measured amount of the milk to be tested. The tain a little phenolphthalein, which is colorless when in acid and pink when in alkaline solution. A solution of these tablets added to the milk and the mixture is stirred until it becomes is then known that enough alkali has been added to neutraliz in the measured amount of milk and the amount of soluti indicates the acidity of the milk.

Perfectly fresh milk contains very little acid and would by the addition of a small amount of alkali, while milk

ains more acid and would require much more of the solution to
it pink. The tablets are made of such strength that, if a solution
vo of them turns one ounce of milk pink, that milk should keep
sonable length of time with proper care. If the milk remains
e after the solution has been added to it, it will probably soon
. This is a very simple, inexpensive, and useful test, and requires
milk enough to fill an ounce bottle. If this test were adopted
ousehold use, one could soon ascertain how much of the alkaline
ion should be necessary to turn a definite amount of milk pink at
ime of delivery, and then refuse any not up to the standard.

has been stated that colostrum, or the first milk given after
ng, contains a large percentage of albumen, and should not be
for ordinary purposes. Albumen is coagulated by heat, and
colostrum is boiled a large coagulum is formed. If perfectly
t milk coagulates on boiling, the indications are that it contains
nuch albumen, and it should not be used.

e foregoing tests are all good so far as they go, but none of
show whether the milk is from healthy cows or whether it has
contaminated by germs of disease. The adulteration of milk may
ice bad results by diminishing the food value, but intelligent per-
will learn sooner or later that they are being cheated, especially
practice is carried on to a great extent. By far the greatest
nt of harm that is produced by milk is due to objectionable bac-
which it contains. An inconceivable number of these organisms
e present in milk and their presence not be noticed, and the only
which they can be detected is to note the changes of the milk
e a bacteriological examination made, which involves time and
se. No test has been devised that will quickly and easily show
esence of disease germs in milk. It has already been stated
acteria get into the milk of healthy cows after it is drawn, and
st way to keep them out is to avoid, as much as possible, expos-
milk to them. This means that the dairy and its surroundings
e clean, and clean all the time. Filth can not be present in
gree without having a contaminating influence.

## SELECTION OF DEALER.

oubtedly the best way to secure a good milk supply is to deal
dairyman or milkman who is thoroughly honest and scrupulously
He should be required to show quarterly certificates from a
arian of good standing, stating that after a careful examination
cows they were found to be healthy; that if the health of any was
oubtful such animal had been removed from the herd; that the
of the feed and water, the sanitary conditions of the stables and

surroundings, and the health of the employees were approved. His own honesty and experience should be sufficient guaranty as to good measure and quality and that his milk has been properly cared for and guarded against exposure. The certificate of the veterinarian should be sufficient guaranty as to the good health of the herd and correct sanitary conditions of the establishment. It is a mistake to consider that milkmen are naturally a lot of tricksters. Honest men are in this business as well as any other, and one of the most important steps toward securing honest milk is to encourage the honest man by giving him deserved trade. The milk commissions operating in some of the large cities serve this purpose. They approve or "certify" the milk of dairies which are conducted in the most careful manner.

Laws have been in force for many years in most of our cities requiring a certain composition of milk as the minimum. Usually the requirement is at least 3 per cent fat and 12 per cent total solids. These regulations are undoubtedly a great benefit so far as they go, but in many towns and cities there are no such laws in force, and in order to secure a good quality of milk the great majority of milk consumers rely on the intelligence and honor of the one who supplies them. One of the best incentives for a dairyman or dealer to keep his dairy as it should be is to feel that he may expect a visit at any time from some of his customers. The practice on the part of consumers of occasionally visiting the farms and stores from which their milk comes can not be too highly commended. When one does this he should take special care to know that he is not visiting a sample farm which is always kept ready for inspection, while others, perhaps more distant, are not in such good condition. His milk may come from those more distant. On a well-conducted dairy farm one may expect to find these conditions:

A roomy, clean, dry, light, and well-ventilated stable or cow house. To produce good milk, cows must be comfortable, and these conditions not only add to their comfort but are absolutely necessary to keep them in the best of health.

Healthy and clean cows, which appear well-fed and contented.

An abundance of pure water to which cows are given access at least twice a day.

Feed of good quality; the grain and coarse fodder should be free from dirt, decay, or a musty condition.

A spirit of kindness toward the stock, exhibited by everyone employed about them, and gentleness of the animals themselves.

Provision for washing and sterilizing or scalding all utensils which come in contact with milk, and preferably the use of milking pails with small top openings, which do much to keep dirt from falling into ilk.

Provision for straining and cooling the milk in a clean atmosphere, free from all stable and other odors. This treatment should take place immediately after the milk is drawn from each cow.

Facilities for storing the milk and keeping it cold.

Especially great cleanliness in regard to everything connected with the dairy. The air of the stable should be pure and free from dust when milking is being done. Employees should carefully wipe the udders and then wash their hands before milking, and should be in clean clothes. Whitewash is a good disinfectant, and should be seen in many more stables, and land plaster should be sprinkled about to absorb moisture and odors. The cow should stand on clean litter and not dirty stuff which could be used nowhere else.

If it is suspected that milk is being adulterated, a sample might be taken by the visitor when on the farm. This should be handled as nearly as possible like the daily supply, and compared with it as to amount of cream, or, better, as to the amount of fat.

If the milk is handled through a store in the city, the building should be kept scrupulously clean, and the room in which the milk is exposed should be free from dust. There should be provision for keeping the milk cold when stored, and apparatus for steaming or scalding all utensils after they are washed.

## TOWN AND CITY MILK SUPPLY.

The average dairy cow gives 350 gallons of milk per year, or about enough to supply 14 persons, provided it is all used as milk. But in all dairy districts more or less butter and cheese are made, and so, within reach of every town or city, there must be at least one cow for about every 12 people. Cows are kept in many villages and in some cities, but the great bulk of milk consumed in cities is produced at some distance from the closely populated section and transported to market by wagons, railroad trains, and boats. Sections are found within easy reach of all cities where dairying is the prominent pursuit and large quantities of milk are produced for shipment. Orange, Dutchess, Sullivan, and Delaware counties are the most important localities near New York City sending milk to that market. Chester County, west of Philadelphia, furnishes that city a large part of its supply. The country west and northwest of Boston furnishes most of its milk. A large part of the supply of Chicago comes from the north, but to the west and south are found excellent dairy lands from which considerable milk is shipped. These dairy sections are famous for their luxuriant pastures, pure cold springs, and fine cattle. In general, these communities are among the most prosperous of the agricultural districts of the country.

## CARE OF MILK ON THE FARM.

Whether milk is delivered promptly or held some time before delivery, it needs particular care, and the best dairymen provide for this purpose a room near the stable, but separated from it so as to exclude dust and unpleasant odors. As soon as a pailful of milk has been drawn from the cows, it is carried to the milk room, poured through a fine strainer, and cooled with an apparatus made of thin metal and containing cold water. The milk flows over the outside of it in a thin sheet. After 20 or 40 quarts have been thus treated a shipping can is filled and set in cold water, or the milk is bottled and kept cold until needed. Some farmers do not use this care, but strain the milk directly into the large can, which stands in any convenient place, usually within the stable. When the can is filled it is placed (as soon as convenient) in a tub of cold water and stirred until partly cooled, then left with the cover ajar until wanted for delivery. Persons handling milk in this way do not appreciate how sensitive the fluid is to foul surroundings and how quickly it will absorb injurious odors. It is fortunate for consumers that milk shows so plainly when it has been carelessly handled. If purchasers are sufficiently watchful they can avoid being supplied with milk which has been improperly cared for. The dairyman should always bear in mind that milk is a food, and he should not leave it unnecessarily in any place where he would be unwilling to have his own food left an equal length of time.

When milk is served soon after milking, in many cases it is not cooled by artificial means, and in small towns supplied by dairymen, who drive in twice each day, it is often delivered "warm from the cow." To many persons this is a guaranty of its purity; but milk served in this way will sour in a short time. Within two or three hours after it is delivered it is likely to be nearer a condition of sourness than milk twelve or twenty-four hours older which was cooled immediately after milking and kept at a low temperature. In some cases the milk delivered in the morning is that of the previous evening, well cooled and kept in a cold place, and the milk delivered in the afternoon is the morning product similarly treated. This is a much better method than the delivery of perfectly fresh warm milk. When but one delivery is made each day, and that in the morning, the production of the same morning and previous evening are usually distributed. Many dairymen do this when they drive directly from the farm to the places of delivery, except when it is necessary to start before the hour of milking; then the milk of the morning and evening of the previous day is taken. During the hottest weather, the evening's milk is sometimes delivered by itself early in the morning, and the supply of the same morning is served later.

## TRANSPORTATION OF MILK.

Necessarily most of the milk served in large cities is older than that served in towns and villages, as it has to come from greater distances, and for this reason special care is required in warm weather to prevent souring. The milk is made as cold as possible on the farm and usually held in cold spring water until time to be delivered at the railroad station. If the distance to market is great, a liberal supply of ice is kept on the cars; some railroads provide refrigerator cars. When the milk is not delivered as soon as received in the city, it is cold stored and is very cold when placed in delivery wagons the next morning. In some cases the morning's and previous evening's milk are sent into the city on trains some time during the day. If the distance is not too great and arrival in the city is early enough, the night's milk is often served as soon as received, and the morning's milk kept for early delivery on the following day. In these cases the city milkman serves milk from twelve to twenty-four hours old; but generally it is older. Railroads entering some of the large cities carry milk from points two to four hundred miles distant. Milk trains bearing the milk of the morning and the previous evening begin arriving in the cities by 8 o'clock in the morning. Those bringing milk from the more remote producing sections come in later in the day, in a few cases late in the evening. This milk is delivered the following day, being twenty-four or thirty-six hours old when it reaches the consumer. Sometimes the milk is held a half or whole day before delivery, making it that much older when consumed. Almost the entire supply of New York and some of other cities is the so-called "railroad milk."

The daily receipts in New York City are over 1,000,000 quarts (including some used in near-by cities), and practically all of this is brought by trains. Philadelphia uses about 300,000 quarts of milk per day, and, being situated in a good dairy country, a considerable part is delivered by wagons directly from the producing farms. Milk carried long distances in refrigerator cars should arrive in the city in as good condition as that which is carried but a short distance with less protection. It may seem to some that milk twenty-four or thirty-six hours old is unfit for use; but if it has been carefully handled from the first it is much better than a supply not so old and not so well cared for. Clean milk that has been cooled as soon as drawn and kept at a low temperature, will change less in two or even three days, and is therefore better, than new milk which has been carelessly handled. Thus it is possible for old milk to be *fresher*, in the usual sense of that term, than new milk.

Milk is usually transported in heavy cans, the most common sizes holding 20, 30, or 40 quarts; the styles in use differ a good deal according to locality. Within the past few years some companies have established bottling stations near their producing farms and transport the milk in jars, which in hot weather are carried packed in cracked ice. This system has many advantages over the use of cans, but is more expensive. At the present time great quantities of milk are bottled by the dealers in their city plants.

The best conducted milk companies draw their supply regularly from the same dairies, and have contracts with the farmers requiring the milk to be produced by healthy cows, strained and cooled immediately, and sent to the city when fresh. Other provisions relate to the care of the herd and dairy, prices, etc.

## DELIVERY IN CITIES.

There are as many different ways of delivering milk as there are of producing it, and not an insignificant part of the trouble which it gives is caused by neglect to properly care for it while being delivered. The large wide-mouth cans which are opened from fifty to a hundred times before they are emptied have their contents thus exposed to considerable dust and dirt. These cans are often carried without ice, even in the warmest weather, and milk can not possibly remain long in good condition when so treated. An improvement over this method is to have a faucet near the bottom of the can and an arrangement to stir the contents, so that milk of uniform quality can be drawn without exposing the entire supply. The faucet, however, should be carefully protected from dust and dirt. In warm weather the cans should be covered with ice or ice water, or at least with a wet blanket, which is some protection.

FIG. 8.—Milk jar.

The cleanest and most satisfactory way of delivering milk is in glass jars or bottles (fig. 8). Every person who is served in this way should be certain that the jars are properly cleaned as soon as emptied, and the dealer should clean and sterilize them as soon as they are collected each day. Bottles are easily cleaned, each one is a measure and prevents over or under measuring, and each bottle of milk is known to contain all the cream belonging to it. Bottles do not hide dirt in the milk, and if they are filled with fresh milk and are allowed to stand quietly a few hours cream will usually show at the time of delivery. They save the milk from being unnecessarily exposed, and if they are filled in the country the milk does not come in contact with city air until it is in the house of the consumer. This last is of considerable importance, as it has been shown that bacteria are very undant in the atmosphere of cities, while in clean country districts few are found in the air. The use of sealed bottles decreases the opportunity for adulteration. Some companies serving a high-class trade with milk, for which special claims of purity are made, seal the jars, as soon as they are filled, with paraffin or metal caps or seals or sometimes with paper labels on which the time of milking may be stamped, and these must be broken before the jar can be opened. It is an excellent plan, and practically removes all chances of the milk being tampered with by driver or servant, and places all the responsibility on the one who bottles the milk; yet this is not effective unless the seal is so prepared and guarded as to prevent its being removed and replaced, or counterfeited. Objections to bottles are: They are heavy, fragile, and so useful in the kitchen that they are not always promptly returned. Paper packages to be used once and then thrown away have been suggested, but not yet perfected.

It is extremely difficult to get the last trace of dirt out of milk; some of the filth is in such fine particles that it will go through fine strainers, and later settle to the bottom of the containing vessel while the cream is rising. This sediment is objectionable and should be kept out in the first place; its presence is not a good argument against the use of jars. The fresher the milk when bottled the more easily the dirt settles, for the same reason that the fat then rises more easily. There should be no such impurity, but if it is to be present it is better to have it in the bottom of the jar than distributed through the milk and held by its viscosity, as may be the case when the milk is in large cans and stirred frequently to keep the cream evenly mixed in. Sediment is gotten rid of in some cases by allowing the milk to stand a while in large cans or vats and then drawing it off carefully for bottling. Filters for straining milk are now used with some success, and the centrifugal separators are being used by a relatively small number of concerns for cleaning or "clarifying" milk.

Large companies or firms handling the milk from many dairies often arrange to have the supply from every separate dairy served on the same route each day, so there will be as little variation as possible in the quality of the milk served to each customer, but some of them use immense tanks and mix all the milk received, which results in all deliveries being of uniform quality. Such companies generally have equipment for making butter from their surplus, so there is less temptation for them to serve old milk than if they had no facilities to "work it up." The health of each employee and his family should be carefully watched. Some companies board their help to enable them to do this.

Persons who sell milk should be reliable and should know much more about it than many of them do. For this reason it would be well if every dealer were obliged to register at the office of some local official and show that he understands something of the proper handling of milk and is able at least to apply some approved test for fat. The registration of milk dealers is now required in some cities.

## PRICE OF MILK.

Farmers producing milk for shipment to city dealers usually receive from 2 to 5 cents per quart in different parts of the country. The price of course depends mainly on supply and demand, but the quality and condition of the milk produced are factors of importance, and the better price commanded by the higher grade product serves as an incentive for the farmer to keep the best cows and adopt the best methods.

The price which the farmers receive varies somewhat with the season of the year, ranging from 2 to 3 cents per quart in summer, while the winter price is about a cent higher. This difference is necessary to induce the farmers to produce milk during the winter when the cost of feed makes production more expensive. In some localities farmers receive less than 2 cents per quart in the summer. This low price tends to encourage the keeping of cows which give a large flow of (usually poor) milk, and the cheapest possible maintenance.

The way milk is handled greatly influences its cost to the producer. If the business is carried on in a slipshod way, milk can be sold at a profit for a low price. But the product of a good herd, well fed and cared for, that has received care in all particulars from the moment it came from the cow and perhaps is served in expensive glass jars, should command a fair price. The extra cost of good stock and buildings, reliable help, the best feed, veterinary and chemical supervision, and superior methods of delivery is considerable, and all should admit that milk produced with such aids is much more desirable and worth more than that produced and handled in a careless manner. *The failure of the general public to recognize this fact and act accordingly is one of the chief reasons for the slow improvement of city milk supplies.*

Other things being equal, the price of milk should depend on its richness. It is most unreasonable for milk containing but 3 per cent of fat to sell for the same price per quart as 5 per cent milk. Many regard all milk as the same, and are satisfied as long as it is sweet and cheap; they are unwilling to pay more for one quality than another. This is just the same as it would be to expect to purchase sirloin steak for the price of round, or the finest of flour for the price of a poorer quality. Four quarts of good milk may contain as much food value as 5 quarts of poor milk, and as it costs more to produce a rich than a poor milk, it is right that it should sell for more.

One thing which adds greatly to the expense of delivering milk in cities is the long distance that has to be traveled to serve a small amount of milk. Sometimes every house in a block is served by a different peddler, and yet all get practically the same kind of milk. This condition can not be easily changed while competition is so strong; but it would be a long step toward reformation and economy in the milk business if consumers and peddlers would cooperate so as to avoid this useless waste of labor.

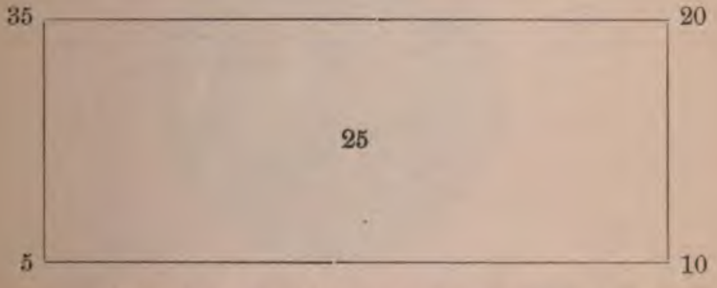
## STANDARDIZING MILK AND CREAM.

It is coming to be a more and more common practice to standardize milk and cream before sale. This means the adjustment of the fat content to a certain desired percentage, and it is accomplished by mixing, in the proper proportion, milk and cream, or two qualities of milk or cream, one richer and one poorer than the desired standard quality. The use of skimmed milk would be prohibited for a milk mixture by the laws of some States and the ordinances of some cities. But normal milk of low enough fat content can usually be found for all requirements.

An easy way to determine the relative amounts of the two milks or creams to be mixed is given in the following rule:

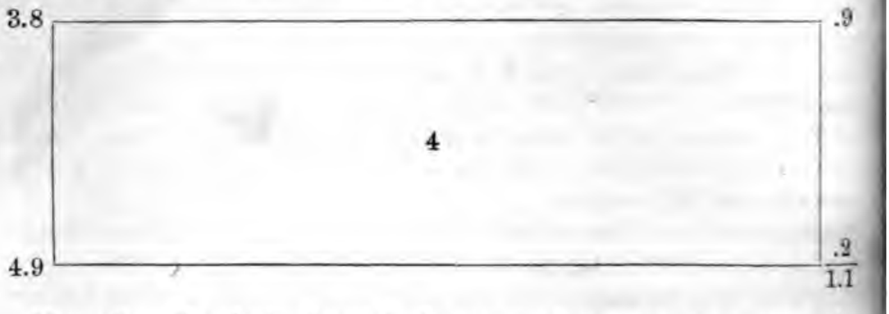
Draw a rectangle (see accompanying diagrams) and write at the two left-hand corners the percentages of fat in the two fluids to be mixed and in the center place the standard percentage desired. Then find the difference between the number in the center and that at the upper left-hand corner, and place this at the opposite corner—the lower right-hand corner. In like manner place at the upper right-hand corner the difference between the number in the center and that at the lower left-hand corner. Now the number at the *upper right-hand* corner shows the relative number of pounds of the milk or cream whose percentage stands at the *upper left-hand* corner, which should be used in making the mixture; and the number at the *lower right-hand* corner shows the relative amount which should be used of the milk or cream whose percentage stands at the *lower left-hand* corner.

For example: Suppose we have a cream testing 35 per cent fat and a milk testing 5 per cent fat, and we want to mix them in such ratio as to produce a 25 per cent cream. Following the rule, we have this diagram:



This shows that 20 parts of the 35 per cent cream should be combined with 10 parts of the 5 per cent milk to produce 30 parts of the 25 per cent cream. In other words, the two may be combined in the ratio of 20 to 10 (or 2 to 1) to produce any desired quantity of cream testing 25 per cent fat.

Or suppose it is desired to mix milk testing 3.8 per cent fat with milk testing 4.9 per cent so as to produce 200 pounds of milk testing 4 per cent fat. The diagram will appear as follows:



Discarding the decimal points for convenience, we can now make up the 200 pounds of 4 per cent milk by taking $\frac{9}{11}$ (or 163.64 pounds) of the amount from the milk testing 3.8 per cent and $\frac{2}{11}$ (or 36.36 pounds) from the milk testing 4.9 per cent fat.

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FARMERS' BULLETIN No. 51.

# TANDARD VARIETIES OF CHICKENS.

BY

GEORGE E. HOWARD.

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Class X—Ornamental Bantams:

Sebright Bantams..........................................(illustrated)..
Rose-comb Bantams ....................................... (illustrated)..
Booted Bantams.................................................................
Brahma Bantams.................................................................
Cochin Bantams.................................................................
Japanese Bantams ........................................(illustrated)..
Polish Bantams .................................................................

Class XI—Miscellaneous:

Silkies.................................................................
Sultans.................................................(illustrated)..
Frizzles.................................................................
Note .................................................................

51

# STANDARD VARIETIES OF CHICKENS.

## CLASSIFICATION.

There are 104 standard and a large number of nonstandard varieties of chickens raised in this country. The standard varieties are divided as follows:

1. American class: Barred, White, and Buff Plymouth Rocks; Silver, Golden, White, Buff, Black, Partridge, Silver-penciled, and Columbian Wyandottes; Black and Mottled Javas; Rose-comb Dominiques; Single-comb and Rose-comb Rhode Island Reds, and Pea-comb Buckeyes.

2. Asiatic class: Light and Dark Brahmas; Buff, Partridge, White, and Black Cochins; Black and White Langshans.

3. Mediterranean class: Single-comb Brown, Rose-comb Brown, Single-comb White, Rose-comb White, Single-comb Buff, Rose-comb Buff, Single-comb Black, and Silver Duckwing Leghorns; Single-comb Black, Rose-comb Black, and Single-comb White Minorcas; White-faced Black Spanish; Blue Andalusians, and Mottled Anconas.

4. English class: White, Silver Gray, and Colored Dorkings; Rose-comb Redcaps; Single-comb Buff, Single-comb Black, and Single-comb White Orpingtons.

5. Polish class: White-crested Black, Bearded Golden, Bearded Silver, Bearded White, Buff-laced, Nonbearded Golden, Nonbearded Silver, and Nonbearded White Polish.

6. Dutch class: Golden-spangled, Silver-spangled, Golden-penciled, Silver-penciled, White, and Black Hamburgs.

7. French class: Mottled Houdans, Black Crevecœurs, and Black La Flèche.

8. Game and Game Bantam class: Black-breasted Red, Brown Red, Golden Duckwing, Silver Duckwing, Red Pyle, White, Black, and Birchen Games; the same varieties for Game Bantams.

9. Oriental Game and Bantam class: Cornish and White Indians, Black Sumatras, Black-breasted Red Malays, and Black-breasted Red Malay Bantams.

10. Ornamental Bantam class: Golden and Silver Sebrights; Rose-comb White and Rose-comb Black; Booted White; Light and Dark

Brahmas; Buff, Partridge, White, and Black Cochins; Black-tailed, White, and Black Japanese; Bearded White, Buff-laced, and Non-bearded Polish.

11. Miscellaneous class: White Silkies, White Sultans, and Frizzles.

For practical purposes the above eleven classes may be grouped into four general classes, as follows:

1. The general purpose breeds: The American class, the Orpingtons, and the Houdans.

2. The meat or table breeds: The Asiatic class, the Dorkings, and the Indian Games.

3. The egg breeds: The Mediterranean class, the Dutch class, and the Redcaps.

4. The ornamental breeds: The Polish, the Crevecœurs and La Flèche, the Game and Game Bantam class, the Oriental Game and Bantam class (except the Indians), the Ornamental Bantam class, and the miscellaneous class.

## CLASS I—AMERICAN.

### PLYMOUTH ROCKS.

The Plymouth Rock is the most popular of all breeds of poultry as a general-purpose fowl. The Barred variety is the best known, and its history dates back over a quarter of a century. Various breeds were used in its making, the belief being general that it originally came from a cross between the American Dominique and the Black Java. It has also been shown that the Light Brahma, Dark Brahma, and Pit Game have been used in its making.

The Barred Plymouth Rock (fig. 1) is of a grayish-white color, each feather regularly crossed by narrow, parallel bars of dark blue-black running in distinct lines throughout the entire length of the feather and showing on the down, or undercolor, of the feathers. The barring is somewhat smaller on the hackle and saddle feathers than on other portions of the body. A medium-sized bird with a broad, full breast, a rather long and broad body, medium-sized wings that fold gracefully, the wing fronts being well covered by the breast feathers and the wing points by the saddle feathers; a moderately large head, ornamented with an upright bright-red comb and wattles; a large bright-red or bay eye, and yellow beak, shanks, and toes places the picture before us.

For the farmer or market poultryman these fowls are favorites, being of medium size, well proportioned, with a deep full breast, making a most admirable bird for market purposes. They are hardy, mature early, and make excellent broilers when from 8 to 12 weeks old. They are good layers the year round, and in winter lay exceptionally well. Their eggs are brown in color and average 8 to a pound. They are good sitters and excellent mothers.

The Barred Plymouth Rock, besides being a practical fowl, is also one of the most sought after by fanciers. No class is better filled at the average poultry show of the country. The graceful figure, upright carriage, and active nature endear it to all as a fancier's fowl. It requires much skill to breed for color, and two matings are generally used. An established rule for mating for cockerels is to use a standard-color male with medium-dark females, and for pullets to use medium-light male and standard-color females. The double mating is resorted to by many, yet rare specimens have been produced from single matings.

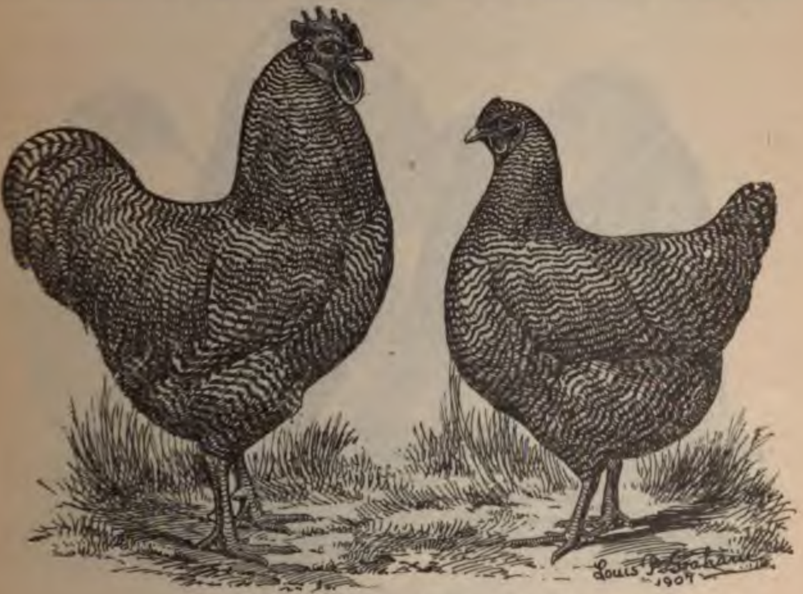

FIG. 1.—Pair of Barred Plymouth Rocks.

The characteristics of this breed are noticeable in the other varieties of Plymouth Rocks, excepting that of color. The size, shape, general outlines, and qualities are the same in the other varieties as in the Barred. The White Plymouth Rock is pure white in plumage throughout, and the Buff variety is a clear golden buff, uniform in shade. The buff should extend to the undercolor as much as possible—the deeper the better.

The standard weight of cocks is 9½ pounds; hens, 7½ pounds; cockerels, 8 pounds; pullets, 6½ pounds.

## WYANDOTTES.

The Wyandotte (fig. 2) is another of the general-purpose fowls and is rated next to the Plymouth Rock. From the first it sprang into popular favor and has continued so to the present time. It came originally from the Dark Brahma, Silver-spangled Hamburg, and the Breda (a French fowl). Not a few authorities say that Wyandottes have Cochin blood in them, from the fact that their ancestors produced single combs and feathered shanks.

For general purposes the Wyandottes have proved a success, being of medium size, weighing on an average a pound less than the Plymouth Rocks, being hardy of constitution, and prolific layers. They are easily cared for and bear confinement well. For table purposes they are of superior worth; their flesh is sweet, juicy, and tender, and they make excellent broilers and roasters. As layers they are among the best, averaging about fourteen dozen eggs a year, and as winter layers they do well under ordinary circumstances.

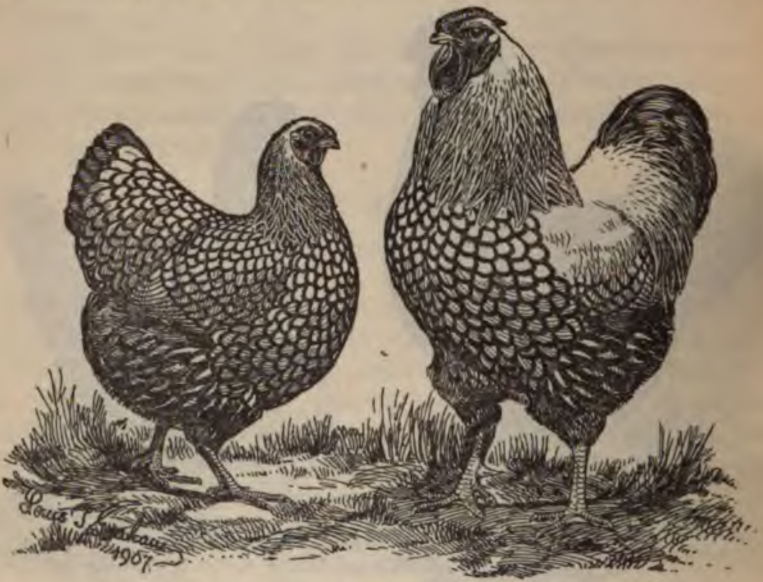

FIG. 2.—Pair of Silver Wyandottes.

There are eight varieties of the Wyandotte breed, and it is only a matter of opinion as to which is the best. The general characteristics are the same in all, the difference in color of plumage being the only distinguishing mark.

The Silver Wyandotte is of a silvery-white plumage, with regularly marked black lacing on the breast and a generous distribution of white and black throughout the entire body. The cock has a silver-white head, rose comb, silver hackle, with a black stripe down the center of each feather; silvery-white back; saddle same as hackle;

breast feathers black, with large white centers; tail black; wings half black and half white, or, rather, black edged with white; when the wing is folded there should be a well-defined bar across it; shanks and toes rich yellow, free from feathering. The hen of the silver variety is marked similarly to the male, excepting the back and wing, which are whiter in the male than in the female. The breast of the female is of much importance in breeding good birds; the lacing should be distinct, and the white centers of each feather free from black or brown penciling.

The Golden Wyandotte is marked like the Silver, excepting that the color is golden-bay and black instead of white and black. The White variety is, perhaps, the favorite from the fact that it is not so difficult to breed to feather, the plumage being pure white throughout. It is for this reason the more practical fowl for the farmer or those who keep poultry for market. The Buff Wyandotte is in color a rich, golden buff, uniform in shade throughout. The Blacks are of a rich, glossy black, with greenish sheen, excepting breast, primaries, secondaries, tail, and fluff, which are pure black.

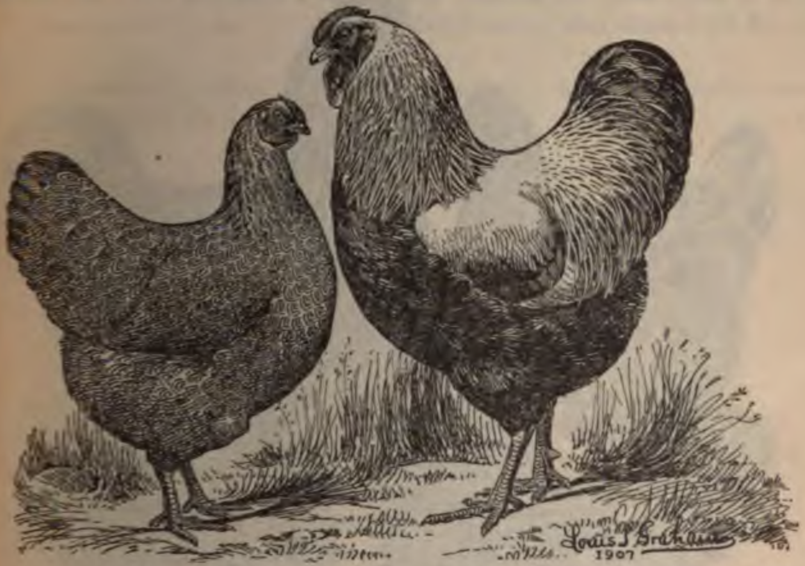

Fig. 3.—Pair of Silver-penciled Wyandottes.

The Partridge and Silver-penciled (fig. 3) Wyandottes are two of the late additions to the standard varieties, the former having been admitted in 1901 and the latter in 1902. The color of the plumage of the Partridge is similar to that of the Partridge Cochin, and the color of the plumage of the Silver-penciled is similar to that of the Dark Brahma.

The Columbian Wyandotte is the latest addition to the standard varieties of this breed. In color and markings it is like the Light

Brahma, which, combined with the true Wyandotte shape, presents a very beautiful bird. The color of the beak is horn, shading to yellow at the point, and the color of the shanks and toes is yellow.

The standard weight of cocks is 8½ pounds; hens, 6½ pounds; cockerels, 7½ pounds; pullets, 5½ pounds.

### JAVAS.

This breed is one of the oldest of the American class, and at one time was considered the most profitable of all breeds. At present Javas are not raised extensively; the more modern or newer breeds have seemingly supplanted them in popularity. There is no reason why this should be so, as they are useful and good general-purpose fowls. In size they are about like the Plymouth Rocks, but differ in general symmetry and appearance. They are good layers and do well in winter, and for table purposes they are quite satisfactory. They mature early, are good sitters and mothers, and are easily kept in confinement.

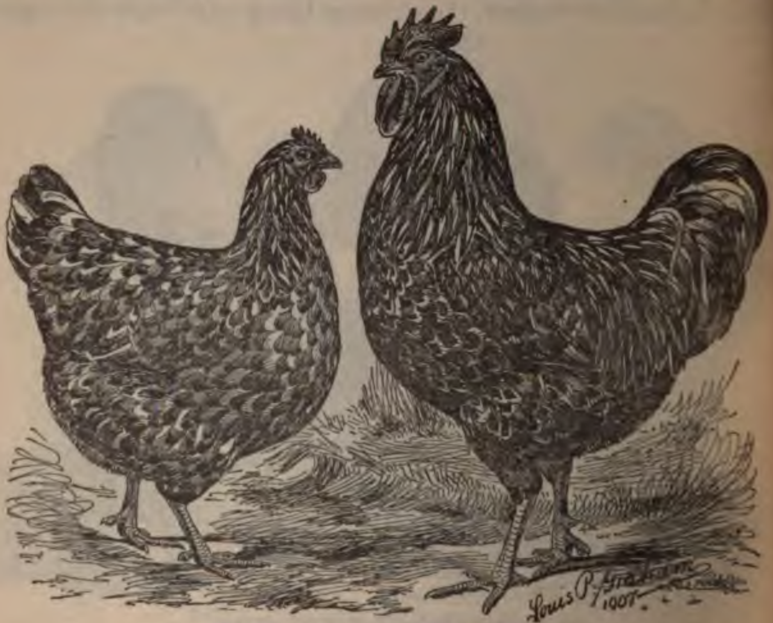

FIG. 4.—Pair of Mottled Javas.

There are two varieties of Javas, the Black and the Mottled. The Black is more generally seen than the Mottled. The plumage of the Blacks is glossy black throughout; the Mottled (fig. 4) is of broken black and white throughout, with black predominating. The Java has a small single comb, standing upright on the head in both male and female. The shanks and toes are free from feathers, black in color, with the bottom of the feet yellow in the Black Java, while the color of the shanks and toes of the Mottled variety should be broken leaden blue and yellow.

The standard weight of cocks is 9½ pounds; hens, 7½ pounds; cockerels, 8 pounds; pullets, 6½ pounds.

### DOMINIQUES.

Similarity in plumage of the American Dominique and Barred Plymouth Rock has been the cause of the former's popularity. The color is grayish white, each feather regularly crossed with parallel bars of dark blue-black, producing the effect of a bluish-tinged plumage, the color being the same throughout. They have rose combs, in both male and female, and bright-yellow legs. Those who are partial to their color of plumage will find the Dominiques good birds to keep. They are good layers, are hardy, mature early, and dress well for the table.

The standard weight of cocks is 8 pounds; hens, 6 pounds; cockerels, 7 pounds; pullets, 5 pounds.

### RHODE ISLAND REDS.

This is one of the new standard breeds which has gained prominence as a general-purpose fowl. They are of medium size, hardy, mature early, lay brown-shelled eggs, and are good sitters and mothers. There are two varieties of this breed, the Single-comb (fig. 5) and the Rose-comb, the only difference being in the shape of the comb.

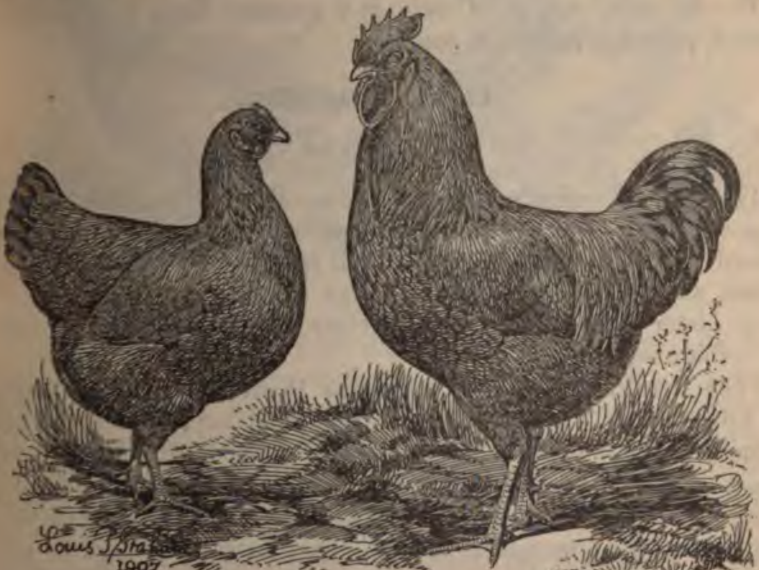

FIG. 5.—Pair of Single-comb Rhode Island Reds.

The color of the plumage of the male should be a rich, bri
red, except in the wings and tail, portions of which should be
A harmonious blending of red is desirable, but in most specim
color is accentuated on the wing bows and back. The plumage
female should be somewhat lighter in color than that of th
Portions of the hackle, wings, and tail are black in color. Th
of both male and female should be reddish horn, the shanks
or reddish horn, and the toes reddish horn in color.

The standard weight of cocks is 8½ pounds; hens, 6½ 
cockerels, 7½ pounds; pullets, 5 pounds.

### BUCKEYES.

This breed was originated by Mrs. Metcalf, of Ohio, and w
duced by crosses of Plymouth Rocks, Buff Cochins, Black-
Red and Indian Games. In shape the Buckeyes resemble so
the Indian Games, but have a more fluffy plumage. In col
should be a dark, lustrous red, never buff or brick color. Th
posed flight feathers and the main tail feathers may be p
black. The color of the beak, shanks, and toes of the male is
shaded with red horn, and of the female yellow. Both the m
the female should have a small pea comb.

The standard weight of cocks is 9 pounds; hens, 6 pound
erels, 8 pounds; pullets, 5 pounds.

## CLASS II—ASIATIC.

### BRAHMAS.

The leading variety of the Asiatic class is the Light
(fig. 6). This fowl has a history that would fill many pages
recorded. These are the fowls which caused the "hen fever
fifties, about which so much has been written in later years
early history is a matter of controversy, the best authorities
as to their origin.

They were first known as "Brahma Pootras," "Gray Sha
"Chittagongs," "Cochin Chinas," and what not. The early
named them according to his fancy for high-sounding and sen
names in order to sell his stock. Fabulous prices were paid f
when the craze for fine poultry was at its height in the early da
last half of the nineteenth century. They have stood high in
favor since then without abatement. The vast number of
who are raising them fully attest their worth to the indus
practical bird. The Brahma is unlike other breeds, and it sh
be confounded in shape with the Cochin. In shape the bod
Brahma is rather long and deep, with full, broad, and roun

carried well forward. The fulness is typical of the Brahma and is characteristic of prolific birds.

In plumage the Light Brahma male is white and black, white largely predominating. Any color but white and black is a fault in the standard-bred bird. The hackle is white with a black stripe extending down the center of each feather and tapering to a point near the extremity. The tail feathers are black, and the sickle feathers are glossy greenish black. The shanks are well feathered, with the feathering extending down the middle toe. The toe feathering may be white, or white sprinkled with black. A small pea comb, a broad crown projecting over the eyes, bright-red face, wattles, and ear lobes are essential to a good head. The shanks and toes are bright yellow.

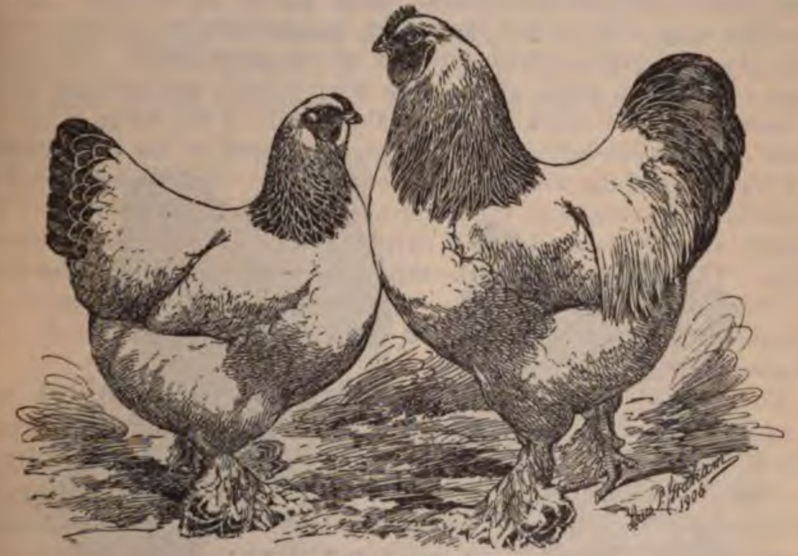

FIG. 6.—Pair of Light Brahmas.

The Brahma female is much like the male in head qualities, having a broad crown, projecting well over the eyes, and a small pea comb. The head is white; hackle, white striped with black, as in the male; tail, black, excepting the two highest main tail feathers, which may be edged with white; tail coverts—one or more rows, distinctly covering a part of both sides of the main tail, two rows being preferable—are black, edged with white.

The Light Brahmas are valuable birds for the farm. They have always been made to pay for their keep and have seldom been set aside by any who have bred them. They are the largest of domestic poultry and do as well in confinement in small runs as on free range. As layers they will average from 12 to 13 dozen eggs a year, and they lay exceptionally well in winter. Their eggs are large, about 7 to a pound, of a rich brown color and excellent flavor. For table purposes the birds are good; they do not mature as early as do the varieties of the American class, yet they are hardy, and can be raised with as much ease as any of the earlier maturing varieties. As sitters and mothers they are fair.

The Dark Brahmas are not so popular as the Light, the difficulty being in breeding them true to feather. Their delicately marked plumage is extremely pretty when they are bred to standard requirement, but if not so bred it becomes most disagreeable and unsatisfactory to the breeder. The head and neck of a Dark Brahma male are similar to those of the Light, the head being white and the hackle rather more striped; the neck other than hackle should be black. The back is silvery white. The saddle feathers are, like the hackle, silvery white, striped with black, which should be distinct. As the feathers approach the tail the stripes become broader till they merge into the tail coverts, which are rich, glossy green-black. The tail is pure black, with green gloss. The wing coverts are greenish black, forming a distinct black bar across the middle of the wings, while the ends of the secondaries have a large black spot on the end, making the top edges of the wing appear almost black. The remainder of the secondaries are white on the lower half and black on the upper. The flights are all black except a narrow fringe of white on the lower edge. The breast is black; the thighs are black, and fluff either black or black very slightly mottled with white. The shank feathering should be black or black mottled with white, black preferred. The shanks and toes are yellow.

The color of females is a white ground, closely penciled with dark steel gray, producing a beautiful effect, silver gray in appearance. There should be no show of pure white in the plumage except in the margins of the hackles. Unless extreme care is taken in mating, the hens are likely to have a dingy color, and the pullets are apt to have necks almost white for some distance down. These light-necked birds are generally unsatisfactory for breeding, but the evil may be remedied by choosing birds for breeding whose heads are distinctly marked. The shape and character of the markings of the Dark Brahma pullets also vary. They should be medium sized, so that the pencilings can be clearly discerned at a short distance. A great point in regard to color and marking in Brahma pullets is that it should be uniform over the body, and the hackles should be silvery white, heavily striped with rich black, and the shank feathering penciled same as body.

For practical purposes the Dark Brahmas are not to be commended as highly as the Light Brahmas. The close breeding for points in feathers is likely to interfere with their productiveness, yet with proper attention and care they can be bred profitably as well as
auty.

The standard weight of Light Brahma cocks is 12 pounds; hens, pounds; cockerels, 10 pounds; pullets, 8 pounds. The standard ight of Dark Brahma cocks is 11 pounds; hens, 8½ pounds; kerels, 9 pounds; pullets, 7 pounds.

## COCHINS.

The four varieties of Cochins are popular with breeders. They e second to the Brahmas in the meat breeds, weighing but a und lighter than the Light Brahma. Old and experienced breeds of Cochins are pronounced in praise of their qualities as profitable wls. They are hardy, fair winter layers of rich, brown, medium-zed eggs, and fairly good table fowls. The chicks grow well and velop rapidly under proper care.

The Buff variety is the most generally bred; their color tone ffers an attraction to fanciers that is hard to resist. Both male and male are of a rich golden buff, uniform in shade throughout, under-olor same as surface color, but of lighter shade and should extend to the skin. In breeding, select females as near as possible to the desired shade of buff, as free from dark or white in wing and tail, and of as even a color as can be. To such females mate a cock of deeper shade. This mating will produce good results in cockerels and pullets. The heavy leg and toe feathering so characteristic of the breed should have constant care and attention. While the feathering should be abundant, all semblance to vulture hock, or stiff feathering, should be avoided.

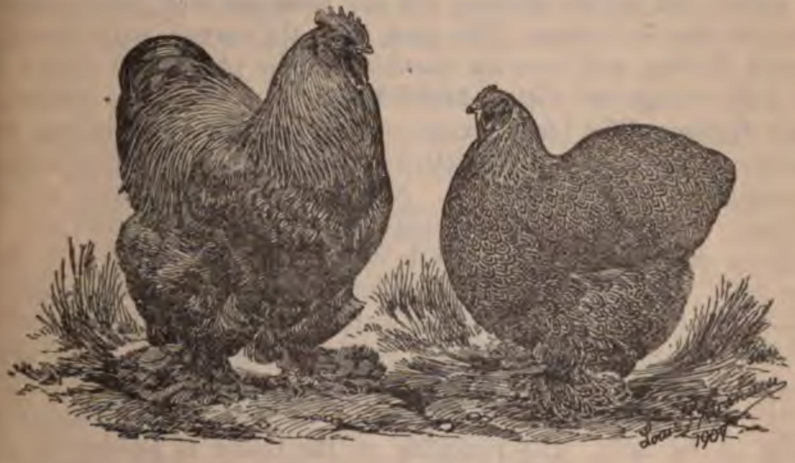

FIG. 7.—Pair of Partridge Cochins.

The Partridge Cochin (fig. 7) is a beautiful fowl, yet difficult to breed, and in plumage is much after the pattern of the Dark Brahma, the color being red and brown instead of the steel-gray rather low, and is partly concealed by the cushion. In color it is black, except the two main tail feathers, which are penciled. The tail coverts are penciled same as breast and body. Thighs are well covered with soft feathers; the feathers on the lower part curve inward around the hock and hide the joint on the outside. The feathering of the thighs is of the same shade and color as that of the body. The shanks are short and yellow and heavily covered with feathers of the same color as the thighs. The toes are well spread and yellow, the outer and middle toes being feathered throughout their entire length.

Black Cochins are much more easily raised than either of the varieties thus far described. Being of one color, the care bestowed in breeding particolored or penciled birds is not necessary, and the time may be spent in furthering their general utility in egg production. A solid-color bird is the more practical bird for the farmer and market poulterer. The Black Cochin is of a rich glossy black plumage throughout.

The White Cochin is pure white in plumage.

The standard weight of Cochin cocks is 11 pounds; hens, 8½ pounds; cockerels, 9 pounds; pullets, 7 pounds.

### LANGSHANS.

Langshans are the smallest and most active of the Asiatic class. They are practical in more senses than one, and their fair laying and other excellent qualities make them profitable for the farmer and market poultryman. They constitute one of the oldest breeds of poultry and have always been held in popular esteem. The shape of the Langshan is distinct from that of the Brahma or Cochin and should not be confused with either of the last-named breeds. Figure 8 shows the accepted contour of the Langshans, and a comparison with the birds in figures 6 and 7 shows at a glance the characteristics of the Langshan as compared with the other Asiatics. Langshans have white flesh and dark shanks, while the others have yellow skin and yellow shanks. The quality of the flesh of the Langshans is excellent, being fine-grained, tender, and nicely flavored. As layers they rank with the Brahma, averaging from 12 to 13 dozen eggs a year and as winter layers they are to be recommended. The chicks are hardy and mature early. Langshans are good sitters and mothers, being of gentle disposition; they are easily kept, either in confinement or on free range. Being excellent foragers, they are ideal fowls for the farm and will gather during the year a considerable proportion of their food.

The Langshan is a stylish, medium-sized bird, not overgrown or gawky in appearance, of active nature, and lively disposition. Many confound the Black Langshan with the Black Cochin. This need not be, as the following comparison between the two varieties shows: The Black Cochin is square in shape, with heavy-looking neck and legs, plenty of fluff and leg feathering, cushion rising from middle of back to tail; tail short and almost concealed by cushion; neck, breast, cushion, and tail all represented by convex lines. The Langshan head is small for the size of the body and the comb is rather large, well up in front, and arch shaped; the Cochin head is larger than that of the Langshan and not so arched over the eye; the comb is smaller, low in front, and almost straight on top of serrations. The back of the Langshan is concave, that of the Cochin is slightly convex, and the Cochin has a large convex cushion. The Langshan fluff is moderate and close; that of the Cochin is extremely full and loose. The wings of the Langshan are of medium size, quite prominent at the shoulders; the Cochin's wings are smaller and almost hidden by the fluffy plumage of the cushion and the fluff. The Langshan's legs are medium in length, the toes are long and tapering, and the color of the shank is bluish black showing pink between scales; the Cochin's legs are shorter and stouter, with larger bone; the toes are shorter and stouter, and the color of the shanks is black or yellowish black.

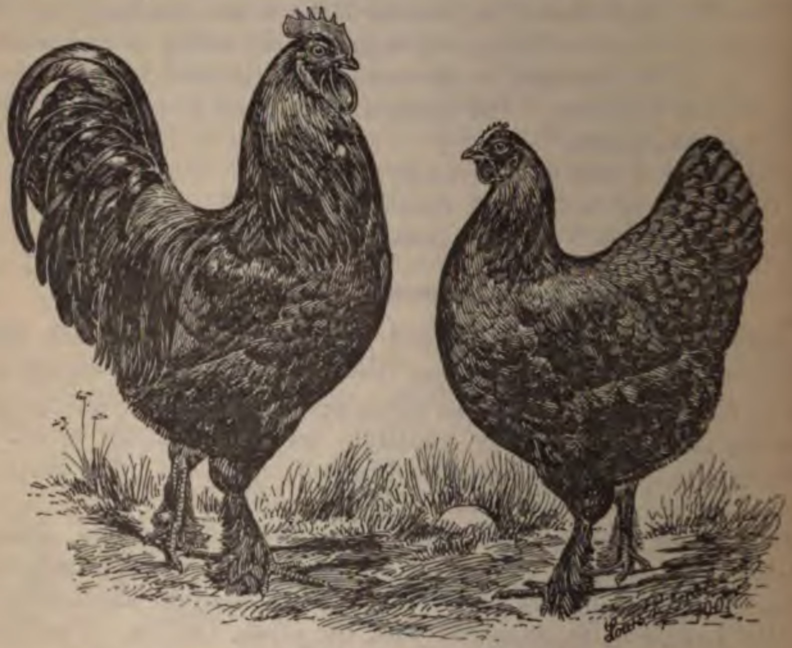

FIG. 8.—Pair of Black Langshans.

There are two varieties of Langshans, the Black and the White. In the Black the plumage of neck, back, saddle, and sickles is a glossy metallic black with greenish sheen; the breast, primaries, secondaries, tail, fluff, shank, and toe feathers are black. The undercolor is black or dark slate. The White Langshan is pure white throughout.

The standard weight of cocks for both varieties is 10 pounds; hens, 7 pounds; cockerels, 8 pounds; pullets, 6 pounds.

## CLASS III—MEDITERRANEAN.

### LEGHORNS.

Leghorns are the best known of the egg-producing varieties, or Mediterranean class. They are the premiers in laying and the standard by which the prolificness of other breeds is judged. As to the origin of the Leghorns there are differences of opinion, and there is but little information to be found anywhere concerning their early history. It is generally conceded that a race of fowls bearing a close resemblance in many respects to the Leghorn has existed in Italy and other parts of the continent of Europe for a long period. That this race has been widely disseminated admits also of little doubt, inasmuch as at the present day it is known in Denmark and other countries as the Italian. There seems to be good ground for the statement that Leghorns were first introduced into America from Italy. The story goes that as early as 1834 a vessel from Leghorn brought to this country as a part of its cargo a small shipment of fowls, which were at once named "Leghorns." They immediately became popular, their prolific laying and nonsitting qualities being recognized at this early date.

White and Brown Leghorns were the first varieties known. Modern breeders are responsible for some of the subvarieties of the breed; and, in point of color at least, exhibition birds of to-day, even of the older varieties, vary considerably from those seen at the present time in Italy.

The Leghorn fowl holds the same place among poultry that the Jersey holds among cattle. The question of profit in poultry has been decided in favor of the egg-producing breeds. Leghorns are lively, active, and of a restless disposition, the best of foragers, and will pick up a good part of their living during the year. They are light eaters, and the cost of raising them to maturity is about one-half that of the Asiatic varieties. They mature early and feather quickly; the pullets often begin laying when 4½ months old, and cockerels crow at a much younger age. They are the best of layers, averaging between 150 and 200 eggs a year. Their eggs are pure white in color and weigh about 10 to the pound. As table fowls they are fairly good; by many they are considered excellent; the only thing that can be said against them is that they are small in size.

Altogether, they are one of the most profitable breeds of poultry
can be kept on the farm, and the cheapness of their keeping
allow the raising of two Leghorns for the cost of one Asiatic. Th
must be dryly housed in winter to lay well and to protect
pendulous wattles from frostbite.

In shape a Leghorn cock should be graceful, with body of med
length, broad at the shoulders, and tapering toward the tail. T
body should be well balanced on a fair length of shank and th
the length of leg giving the bird its sprightly and proud carri
Closeness of feathering adds to the general shape. The breast sh
be full, beautifully curved, rather prominent, and carried well
ward; neck, long and well arched; back, of medium length,
saddle rising in a sharp, concave sweep to the tail; tail, large,
carried at an angle of 45° from the horizontal; the full, flowing
and long, well-curved sickles are characteristics of the bird that
much desired. The wing is long, well folded, and tightly carr
The hackle and saddle feathers are long and abundant, flowing
over the shoulder and saddle. The shanks are free from feath
The head is the prettiest portion of the bird, being short and d
with full, bright-red eyes, and bright-red face. The comb, if sin
should be of medium size, perfectly straight and upright upon
head, free from side sprigs, deeply serrated with five points,
bright red. The comb should extend well back over the head, wit
tendency to follow the shape of the neck. Ear lobes should be w
or creamy white.

The Leghorn hen in many respects resembles the cock, excep
carriage of comb and sexual differences. In shape and carriage
hen is even more graceful and sprightly than the cock, very clo
feather, and rather small in body. Her breast is full, very ro
and carried high; legs fairly long, and shanks thin; tail carrie
an angle of 40° from the horizontal. Her comb is the marvel of
beauty; in the single-comb varieties it falls gracefully to one
but not in a limp manner nor so as to obscure the sight. Legs, c
and face are the same color as in the male, but the ear lobe is n
smaller.

There are eight standard varieties of Leghorns: The Single-
and Rose-comb Brown, Single-comb and Rose-comb White, Si
comb and Rose-comb Buff, Single-comb Black, and Silver D
wing.

The Brown Leghorns (fig. 9) are one of the prettiest of the
horn varieties, but they are the most difficult of all to bree
feather. They have merited the confidence of poultry lovers
long time; their hardy constitutions have withstood rough usage
promiscuous interbreeding has not effaced their characteristics.

are a fixed variety, and their merits are noticeable from the newly hatched chick to the oldest specimen.

In mating Brown Leghorns the most successful breeders use a double mating, one pen for each sex. Fine birds, both cockerels and pullets, can be bred from the same pen by using slightly different types of females. The same male often will breed the finest of both exhibition cockerels and pullets, but it is a rare case to have a female breed both sexes of a remarkable quality. When two pens are used, at the head of the pen mated to produce the cockerels place a fully developed cock with no serious fault, of standard color, especially strong in comb, lobe, hackle, and saddle, a dark undercolor being preferred. To him mate hens of a shade darker than standard, with small, evenly serrated, standing combs; a trifle brick color on wings is no objection, as it will give a brighter color on wing bows of the cockerels. Shafting on the back will also help the black stripe in the saddles. The pullets raised from this pen will be too dark for exhibition, but they will be a great help in breeding cockerels the next season. The male at the head of the pen mated to produce the pullets should be from a pullet strain, and bred directly from an exhibition hen. His color should be a trifle light; comb large, but evenly serrated, if thin near the top all the better; hackle well striped, but no striping in saddle; undercolor of hackle and saddle may be light gray or white; wing bows should show more purple than red, as too much red shows signs of being bred from a "bricky" hen. To him mate exhibition females having light brown penciled with

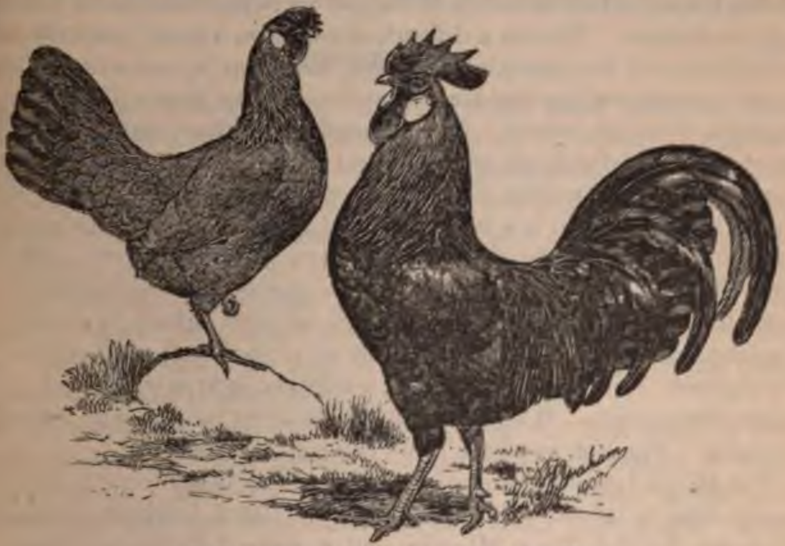

FIG. 9.—Pair of Single-comb Brown Leghorns.

darker brown on back and wings, all one shade, free from shafting on back or brick color on wings. These hens should have the large comb, lying over, but firm and strong on the head, so it does not lie close to the eye and face. The cockerels raised from this mating are the birds to use for breeding females the next year. By breeding Brown Leghorns in this manner we have two distinct lines of blood, which should never be crossed.

The White Leghorn is the most generally bred of the Leghorn varieties. It is, no doubt, the most advantageous to breed for profit, and the easiest to raise on the farm. Being of one color in plumage, these birds are more successfully raised and cared for than the parti-colored varieties. Their plumage is pure white throughout, and feathers other than white will disqualify them. It has been a matter of much speculation as to which variety of Leghorns is most prolific in egg production. This is a difficult question to adjust properly to the satisfaction of the specialty breeders, but from a conservative standpoint it is generally considered that the Whites have slightly the advantage over the others. Phenomenal individual egg records have been made by almost all varieties, but the foregoing opinion is based upon the general results obtained from various sources.

The Buff Leghorn is a beautiful bird and one that will win its way wherever bred. Buff-colored birds have many admirers, and those who have bred them are pronounced in praise of their qualities. Besides having the general characteristics of the Leghorn type, the Buff Leghorn cock has a plumage of an even shade of rich golden buff throughout. The undercolor is of a slightly lighter shade, but even in color throughout. White and black feathers in plumage are objectionable. The hen is of the same color as the cock.

The Black Leghorn is a popular bird and a favorite with those who are partial to its color of plumage. The Black Leghorn is mistaken by many for the Black Minorca, but is quite different in type. The Minorca is larger in size, has a longer body, larger comb, and dark slate or nearly black shanks and toes. The plumage of the Black Leghorn is a rich glossy black throughout. The comb, face, and wattles are bright red, the ear lobes white, and the shanks yellow or yellowish black.

Silver Duckwing Leghorns are not generally bred in this country, though they are frequently seen in the showrooms. They are considered as profitable as any of the other Leghorn varieties, and in point of beauty they are very interesting and fascinating. The hackle feathers of a Silver Duckwing Leghorn cock are pure silvery white, without the slightest straw or creamy tinge, with a narrow black stripe along the center of the lower hackle feathers; back, saddle, and wing bow, silvery white; breast, under parts, wing bar, and tail, lustrous black. The Silver Duckwing Leghorn hen has a silvery gray hackle, with a narrow black stripe through the center of each feather. The breast is light salmon, shading off to gray toward the sides; the body color, when viewed at a short distance, should appear gray, with a faint bluish tint all over. A tendency to ruddy gray, either in ground color or penciling, is objectionable. The tail is black, except the two upper feathers, which are light gray. The penciling or markings are irregular or wavy.

The only distinguishing difference between the single-comb and rose-comb varieties is in the comb. The Rose-comb Leghorns have a small rose comb, square in front, firm and even upon the head, tapering evenly from front to rear, without inclining to one side, the top comparatively flat and covered with small points, terminating in a well-developed spike in the rear. There is no standard weight given for Leghorns.

## MINORCAS.

The Minorcas belong to the Mediterranean class, and they are placed next to the Leghorns in laying qualities. They are in appearance very similar to the Leghorns. Their general outline is, in fact, that of the latter, but with more length of body and heavier in mold. The origin of the Minorcas, like that of so many others of our profitable poultry, is much in doubt. Some persons are of the opinion that they originally came from Minorca, one of the Balearic Isles, in the Mediterranean Sea, while others contend that they are a variety of the Black Spanish. Be that as it may, they are one of the most profitable breeds of poultry for the farm.

The Minorcas are good for table purposes, the flesh being white or light colored and fine grained. Their chief advantage is their egg production. They are nonsitters and year-round layers. As winter layers they are exceptionally good when kept under fairly favorable circumstances. While the Leghorn surpasses them in the number of eggs laid, the Minorca's eggs are larger and equal the output in bulk. Their eggs are white and average 8 to the pound. They lay from 14 to 15 dozen a year. Being of an active, restless disposition they keep in splendid condition and make good foragers. For suburban poultry keeping they are very useful birds, and net good results to the keeper. They are hardy, easily raised, and mature quickly.

The Minorca fowl (fig. 10) is large in outline, well bodied, stands well up on its legs, has a broad chest, and a long, broad back, with tail carried at an angle of 40° from the horizontal. The body of the Minorca male is long, broad, deep, tapering from front to rear. Thighs are stout; shanks, long, stout in bone, and in color dark slate or nearly black in the black varieties, and white or pinkish white in the white variety. The comb of the Minorca is larger and more bulky than that of the Leghorn. The wattles are thin and pendulous, corresponding with the size of the comb; the ear lobes are pure white. The female is in body of the same general appearance as the male, rather long, broad, and deep. Her comb is perceptibly larger than that of the Leghorn female. Black Minorcas are in plumage a rich, glossy, greenish black throughout, and gray tips are considered serious defects. The White Minorca is not quite as popular as the Black. The standard qualifications as to shape are the same for the two; in color the white variety must be pure white throughout, feathers other than white disqualifying. The comb, face, and wattles are bright red, the face being free from white; the eyes are dark hazel in the Black variety and red in the White variety.

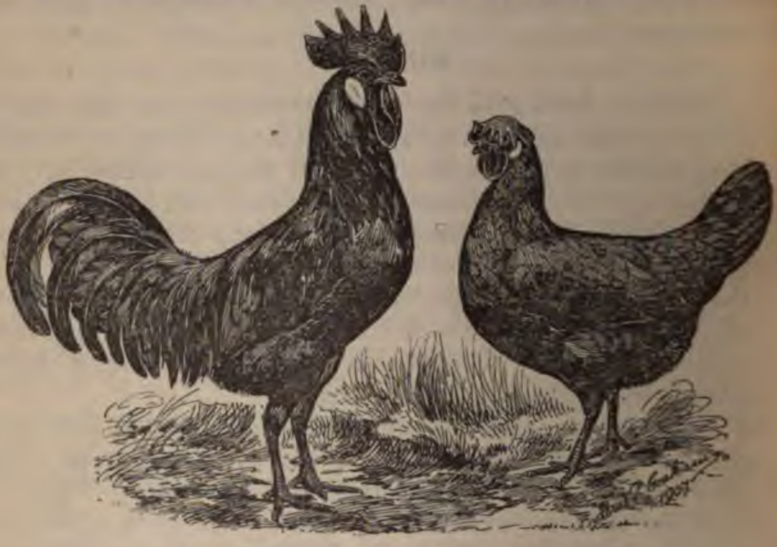

FIG. 10.—Pair of Single-comb Black Minorcas.

Before concluding in regard to Minorcas it is worthy of note that the latest acquisition to the breed is the Rose-comb Black Minorca, which is now a standard variety. The only objection that has ever been raised against the varieties of the Mediterranean class is their susceptibility to frostbite of the comb. Their combs are so large that continued cold or exposure is sure to result in this injury. To obviate this one defect, if it may be so termed, in this valuable class of birds has been the purpose of breeders in producing a bird that possesses the other qualifications, but with a low rose comb. The comb of the Rose-comb Black Minorca male should be rose, square in front, and set close and even on the head. The head of the female is similar to that of the male.

The standard weight of Single-comb Black Minorca cocks is 9 pounds; hens, 7½ pounds; cockerels, 7½ pounds, and pullets 6½ pounds. The standard weight of Rose-comb Black and Single-comb White Minorca cocks is 8 pounds; hens, 6½ pounds; cockerels, 6½ pounds; pullets, 5½ pounds.

### BLACK SPANISH.

The Black Spanish fowls (fig. 11) constitute one of the oldest varieties of domestic poultry. Their name has been identified with the industry for hundreds of years, and their practical worth on the farm has long been recognized. Their haughty bearing, large red comb and wattles, and the white face and lobes peculiar to the breed, contrasting with their glossy black plumage, render them most striking birds.

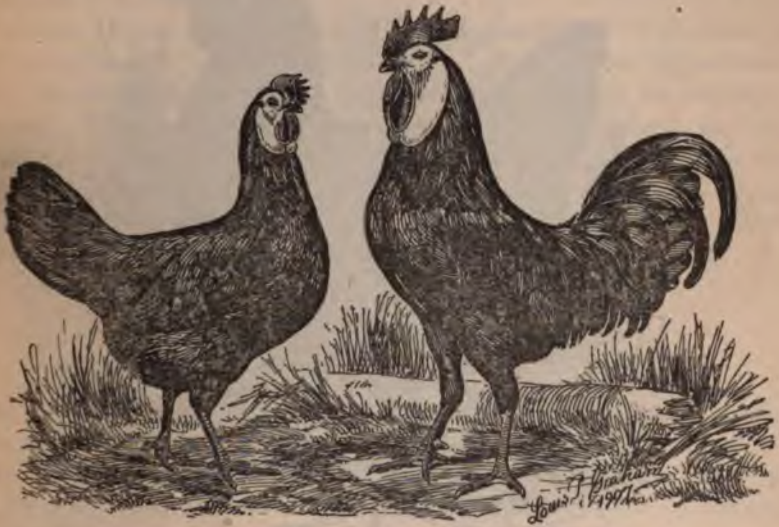

FIG. 11.—Pair of White-faced Black Spanish.

White-faced Black Spanish have long been favorably known for their exceptionally fine laying qualities. The pullets are early layers, averaging 150 to 180 eggs a year; the hens begin somewhat later, after molting, but compensate for any loss in number by the increased size of the eggs. Hens and pullets alike are well above the average for winter laying. Their eggs are large and white and of good flavor. The white face is a distinguishing feature and should be long, smooth, free from wrinkles, rising well over the eyes in an arched form, extending toward the back of the head and to the base of the beak, covering the cheeks and joining the wattles and ear lobes; the greater the extent of surface the better. It should be pure white in color. The color of plumage throughout is rich greenish black, and any gray is considered a serious defect. The shanks and toes are blue or dark leaden blue. The comb is single and bright red in color. The wattles of males are bright red, except the inside of the upper part, which is white; and of females bright red; the ear lobes are pure white.

The standard weight of Black Spanish cocks is 8 pounds; hens, 6½ pounds; cockerels, 6½ pounds; pullets, 5½ pounds.

### ANDALUSIANS.

The Andalusian (fig. 12) is one of the prettiest of the feathered race, being of a beautiful light and dark blue plumage. It is called the Blue Andalusian, and is the only variety of its breed. It is not as popular in this country as it should be, owing to the sentiment against white skin and blue shanks. English and French poultrymen prefer these qualities in a bird, and with them it is very popular. The hens are nonsitters and splendid layers of large white eggs, nearly equaling in size those of the Minorcas. The chicks are hardy and mature early, and the pullets begin laying when five or six months old.

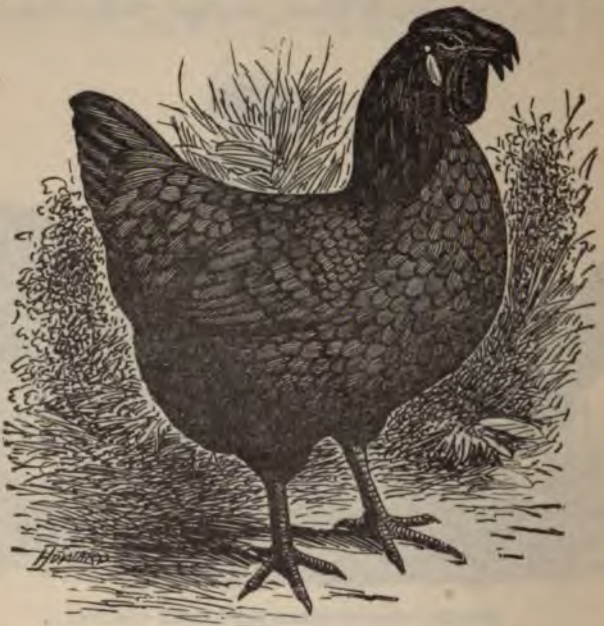

FIG. 12.—Blue Andalusian hen.

For farm purposes the Andalusians rank with the Leghorns and the Minorcas, the preference being only in the color of their plumage. For fancy purposes they are an ideal bird on account of their beauty.

The hackle and saddle feathers are dark blue, approaching black; breast a lighter shade of blue, each feather having a well-defined lacing of a darker shade; body and fluff similar in color to breast; primaries, slaty blue; secondaries and wing coverts, similar in color to breast; wing bows, darker blue, approaching black; tail and sickle feathers, dark blue, approaching black; shanks and toes, blue or leaden blue.

The standard weight of cocks is 6 pounds; hens, 5 pounds; cockerels, 5 pounds; pullets, 4 pounds.

### ANCONAS.

The Mottled Anconas are one of the least common varieties of the Mediterranean class. They are hardy, quick to mature, and prolific layers of white-shelled eggs.

In shape Anconas should be the same as Leghorns. The color of the plumage should be a beetle-green ground, each feather tipped with white; the mottling should be even throughout, with no tendency to lacing. The eyes, face, comb, and wattles should be red, and the ear lobes white. The color of the beak should be yellow, with the upper mandible shaded with black, and that of the shanks and toes should be yellow, or yellow shaded or mottled with black. There are no standard weights for Anconas.

## CLASS IV—ENGLISH.

### DORKINGS.

The Dorking (fig. 13) is one of the oldest of domestic fowls. There are no definite records to show when it first lived in England, or whence it came, but the supposition is that it was carried to England by the Romans, who evidently possessed chickens of similar characteristics.

The chief distinctive mark of the breed is the presence of a fifth or supernumerary toe, springing behind, a little above the foot and below the spur. It has been sought by various writers to deprive Dorking (a town in the County of Surrey, about 20 miles south of London) of the honor of being the original and principal rearing place of this justly celebrated breed, and it is asserted that the true Dorking fowls are raised at Horsham, Cuckfield, and other places in the Weald of Surrey, and that the ancient and superior white fowls from Dorking are a degenerated race compared with the improved Sussex breed. The feature in which this bird is most popular is its table qualities. The flesh is white and very delicate in texture. It is claimed by many to equal if not to excel the French varieties. The broad, deep, and projecting breast of the Dorking admirably fits it for table purposes, and in this respect it is conceded by some to rival the Indian Games. As layers the Dorkings are considered rather indifferent, but they are careful sitters and attentive mothers.

There are three varieties of Dorkings—the White, Silver Gray and Colored. The White Dorking is really the purest blooded of the three, as for years this was the only variety which produced invariably the fifth toe, although the Colored and Silver Gray varieties seldom fail to breed this peculiarity. In color the White Dorking is of clear, unblemished white. The comb and wattles are a bright red; the shanks and toes are white.

Silver Gray Dorkings are beautiful in plumage. The head of the cock is silvery white; hackle, silvery white and as free from stripes as possible; comb, face, ear lobes, and wattles, bright red; beak, white, streaked with horn; eye, bright red; breast, thigh, and underparts, black; back, saddle, and wing bows, pure silvery white; wing coverts, greenish black; primaries, black, edged with white; secondaries, black on upper web, white on lower web, with a black spot at the end of each feather; tail, greenish glossy black; shanks, feet, and toe nails, white. The eye, beak, comb, face, wattles, shanks, feet, and toe nails of the hen are the same as in the cock; head, silvery white; hackle, silvery white, clearly striped with black; breast, salmon red, shading off to gray in the lower parts; back, wing bows, and wing coverts, bright silver gray, with minute pencilings of dark gray on each feather, the shafts of the feathers being white; primaries, upper web dark slate, lower web slaty gray; secondaries, same as primaries; tail, dark, penciled with gray on outside and dark slate on inside.

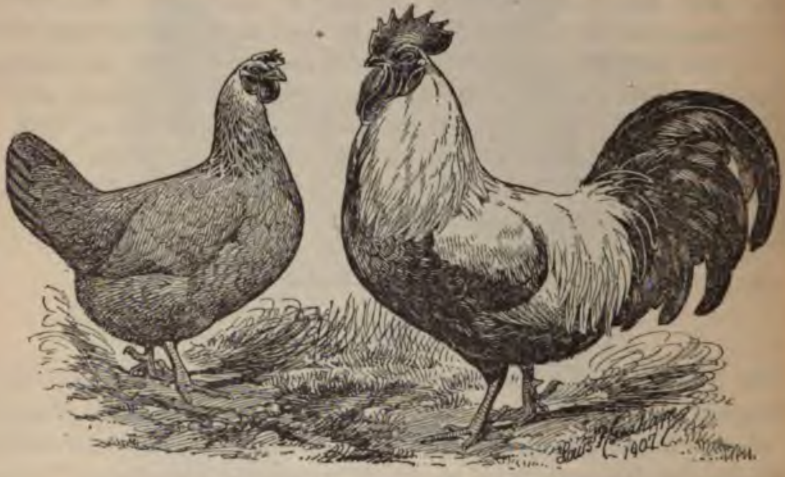

FIG. 13.—Pair of Silver Gray Dorkings.

Colored Dorkings differ from the others only in color, the general olor of the male being black and straw color, while the female is narked with black and mixed gray, with breast of dark salmon edged vith black. The combs of Dorkings differ in the three varieties; the Vhite has a rose comb, Silver Grays and Colored have single combs.

The standard weights for Dorkings differ. The weights for Whites re: Cocks, 7½ pounds; hens, 6 pounds; cockerels, 6½ pounds; and ullets, 5 pounds. For Silver Grays: Cocks, 8 pounds; hens, 6½ ounds; cockerels, 7 pounds; pullets, 5½ pounds. For the Colored: ocks, 9 pounds; hens, 7 pounds; cockerels, 8 pounds; pullets, 6 ounds.

### REDCAPS.

Redcaps are an old breed, mention of them being made by some of he old authors. The large comb stands in their way as popular irds, and unless it is square and even it makes a miserable sight.

Redcaps mature early and are good layers. For market purposes ey are good, the size and quality of flesh being recommendations r popular favor. They are reputed to be nonsitters, though occaonally they are known to sit and hatch broods.

The comb is rose, large, not overhanging the eyes, square in front, d uniform on each side. It must be firm and even upon the head, ithout inclining to one side, the top covered with small points, terinating at the rear in a well-developed, straight spike, and bright ed in color. Wattles and ear lobes are also bright red. In plumage e male and the female are red, brown, and black; the head of the ale is red, with blue-black hackle, each feather edged with red; the ack is red and black, and the breast purplish black.

The head plumage of the female is brown in color; the neck black, ach feather laced with golden red; the back brown and black, and e breast the same color. The shanks and toes are slate-colored or aden blue.

The standard weight of cocks is 7½ pounds; hens, 6 pounds; cockerels, 6 pounds; pullets, 5 pounds.

### ORPINGTONS.

These fowls constitute our most recent importation of a breed from England. They were originated by William Cook, of Orpington, ounty of Kent, England. They are a good general-purpose fowl, eing of good size and good layers of brown-shelled eggs.

There are ten distinct varieties of this breed—the Single-comb Buff, ingle-comb Black, Single-comb White, Single-comb Spangled, Sinle-comb Diamond Jubilee, and the Rose-comb varieties of the same colors. Of these ten varieties only the first three have at present gained admission to the American Standard of Perfection.

The standard Orpington (fig. 14) should have a medium-size single comb, perfectly straight and upright; the neck should be well arched and have an abundance of hackle feathers; the body should be long and broad, with a broad, deep breast and a long, broad back; th wings should be of medium size and nicely folded; the tail should b of medium length, fairly well spread, and carried at an angle of 45 from the horizontal in the male and at an angle of 40° from the hori zontal in the female; the thighs and shanks should be rather shor and stout, and the toes should be of medium length and straight Shanks and toes should be perfectly free from any feathers or down The skin should be white or pinkish white in color, and the face comb, wattles, and ear lobes bright red.

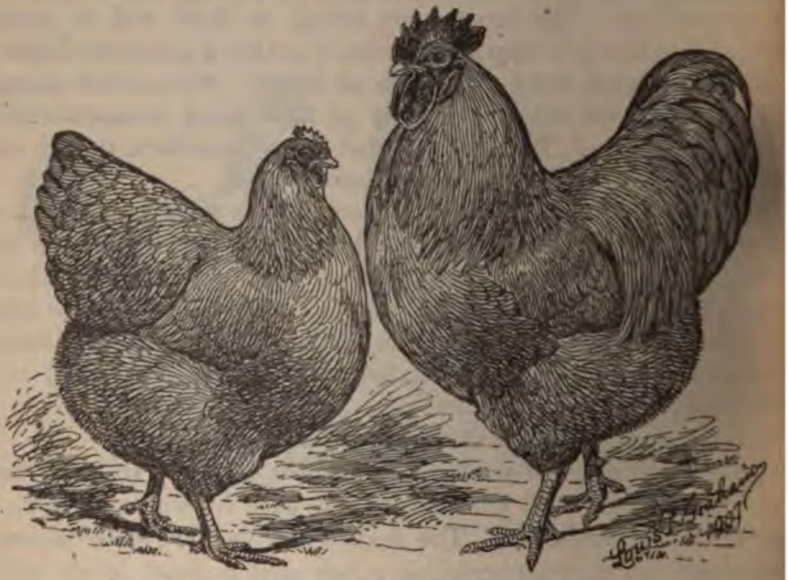

FIG. 14.—Pair of Single-comb Buff Orpingtons.

The color of the surface plumage of the Buff variety should be rich golden buff throughout, the head, neck, hackle, back, wing bow and saddle being richly glossed with a metallic luster. The bea shanks, and toes should be white or pinkish white in color. Th color of the surface plumage of the Black variety should be black greenish black throughout. The beak should be dark horn, shading a pinkish tint near the lower edge. The shanks and toes should bluish black in color; web and bottoms of feet, pinkish white. T plumage of the White variety should be pure white throughout; t beak, shanks, and toes, white or pinkish white in color.

The standard weight of cocks is 10 pounds; hens, 8 pounds; coc erels, 8½ pounds; pullets, 7 pounds.

## CLASS V—POLISH.

One of the oldest breeds of poultry is the Polish (fig. 15), its ancestry being traced as far back as the sixteenth century. Among the varieties mentioned in those early days was the "Woolly" fowl, similar to the silky fowl of to-day. Mention in history is also made of the "Frizzled" fowl, the "Persian" fowl, the "Turkish" fowl, and the "Crested" fowl. The latter is described as being a fowl with a lark's crest. Another variety is known as the "Patavinian" fowl, which is believed to be the progenitor of the Polish breed. The cock is described as exceedingly beautiful, being richly decorated with five colors, black, white, green, red, and ocher. The body is black, the neck covered with white feathers, and the wings and back partly black and partly green; the tail is the same, but the roots of the feathers are whitish, and some of the flight feathers are also white. The eyes are surrounded with red circles, the comb is very small, the bill and feet are yellow, and the head is adorned with a beautiful crest. In the hen there is no white except the white pellicle at the opening of the ears. She is altogether of a greenish-black color, with yellow feet and a very small comb slightly tinged with red.

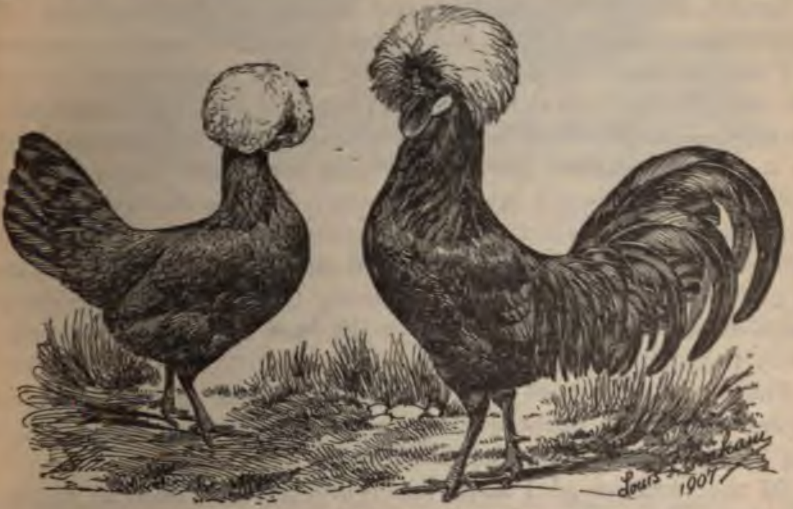

FIG. 15.—Pair of White-crested Black Polish.

The general characteristics of the Polish are those of small to medium sized fowls, larger than the Hamburgs; a full, round breast, carried well forward; the neck of the cock beautifully arched; a straight back, broad at the shoulders, and narrowing rapidly to the tail; large and closely folded wings; a large, well-expanded tail, which in the cock is furnished with an abundance of tail coverts and sickle feathers; shanks of a blue or slaty-blue color in all varieties but the White-crested Black, in which they are of blue or dark leaden blue; and, above all, a large crest and a small V-shaped comb. The crest of the cock is composed of narrow feathers, something like those which form the hackle of the neck and saddle. They should rise well in front, so as not to obstruct the sight, and fall over the back and sides in a flowing, even mass. If they fall forward, as is sometimes the case, they both obstruct the sight and are liable to get wet when the bird drinks. Such a crest, also, is hollow in the center and loses much of its beauty. The crest of the hen should be large and globular in form and compact in character, with no sign of parting. The larger the crest the better, provided it is of good shape; but a close, compact, well-formed crest is to be preferred to one that is larger, but of loose texture and falling in all directions. The smaller the comb the better, and natural absence of comb is preferred.

Polish chickens are bred extensively in this country and by some are considered practical for general purposes; but, while some breeders may secure good results, the Polish is not to be fully recommended as a general-purpose fowl. They are considered more as fancy birds and are generally bred for pleasure and the showroom. Their large crests are against them, hindering their vision and causing them to become listless, inactive, and suspicious. Extra care must be given to be fairly successful in raising them, and their houses and coops must be kept absolutely dry; the least water in their crests is likely to result fatally to them.

They are fairly good layers of medium-sized eggs and are nonsitters. For table purposes they are considered good, their flesh being fine-grained, tender, and sweet.

Of the varieties of Polish, the White-crested Black is the most popular. The color of the plumage of this variety is a rich, glossy black throughout, with the exception of the crest, which is pure white; a narrow band of black feathers at the base of the crest in front is allowable, but the fewer the better. The shanks and toes are blue or dark leaden blue; comb and wattles are bright red, and ear lobes are white.

The Golden and Silver varieties are beautifully marked in plumage. In the Golden the feathers are marked with rich golden bay and laced with black. The feathers of the Silver are silvery white, instead of the golden bay, and are laced with black. The illustration (fig. 16) shows the general markings of the feathers. The White Polish is pure white throughout the plumage. The feathers of the Buff Laced should be of a rich buff color with a narrow white lacing.

There are two distinct subbreeds of Polish, the plain (nonbearded) and the bearded. The latter has a thick, full beard, running back of e eye in a handsome curve, and in color corresponding with the lance of the plumage. The eight varieties of Polish are: White-ested Black, Bearded Golden, Bearded Silver, Bearded White, Buff

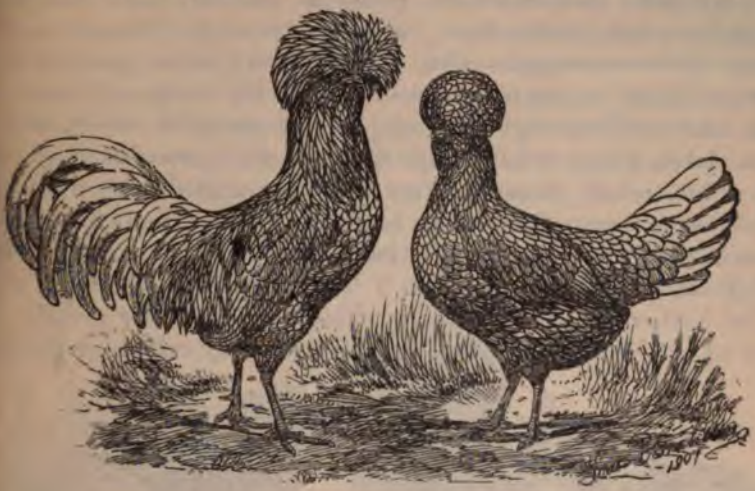

FIG. 16.—Pair of Bearded Silver Polish.

ced, Nonbearded Golden, Nonbearded Silver, and Nonbearded hite.

No standard weight is given for Polish; they are of medium size, out that of Leghorns.

## CLASS VI—DUTCH.

### HAMBURGS.

Hamburgs (fig. 17) are in the front rank of egg producers. There e six varieties of this breed: The Golden-spangled, Silver-spangled. olden-penciled, Silver-penciled, Black, and White. They are all ry pretty birds, and seldom fail to prove attractive and profitable the average breeder and fancier. Hamburgs are economical fowls keep; besides being light eaters and great foragers, they are pro-ic layers and nonsitters. The only thing against them is the allness of their eggs. They lay a pretty, white-shelled egg, but aller in size than those of the Leghorn. There are some which y larger eggs than others, and by careful selection from year to ar of the birds which lay the largest eggs this defect may be reme-ed and the size of the eggs improved.

The Silver-spangled Hamburg is perhaps the most beautiful as ell as the most popular variety of the Hamburgs. Its proud car-age and graceful and symmetrical form command attention when-er seen. Breeders of Hamburgs universally adopt the following as a standard for the breed: Comb, rose, square at front, taperi nicely into a spike, which inclines upward slightly; top of co covered with small points, firmly and evenly set on the head; fa red; ear lobes, moderate size, round as possible, and clear whi shanks and toes, leaden blue; carriage, graceful; plumage, prof Cocks: Silver-spangled—color, clear, silvery-white ground, ev feather tipped or spangled, the bars of the wing regular; ne back, and saddle nicely spangled; Golden-spangled—color, bay a black; back, glossy reddish bay, spangled with greenish black; ne and saddle nicely striped. Hens: Silver-spangled—the white cl and silvery; the spangles large, black as possible, distinct and clea Golden-spangled—rich reddish bay ground; clear spangles, lar and distinct.

The feather markings of the penciled varieties differ greatly fr those of the spangled, the latter being commonly called "moon-ey

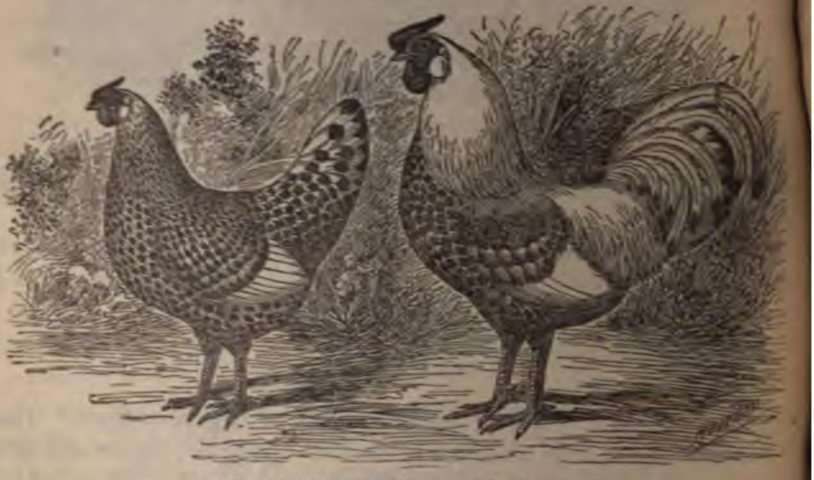

FIG. 17.—Pair Silver-spangled Hamburgs.

from the round or oval appearance of the spangles, while the mark ings of the penciled varieties are in parallel bars of reddish bay o black, or clear silvery white and black, as the case may be. Whi and Black Hamburgs are solid white or solid black in plumage.

No standard weight is given for Hamburgs.

## CLASS VII—FRENCH.

### HOUDANS.

The three varieties of poultry in the French class are the Houdans Crevecœurs, and La Flèche. Of these the Houdans (fig. 18) ar conceded to be the most popular and profitable, being bred to a gre ent throughout the entire country. They are hardy and prolific ers of large, white eggs. For table purposes they are among best fowls. They have small bones and the flesh is tender and icious. The chicks are sprightly and active and feather rapidly. ey are nonsitters and light feeders. Like the Leghorns, they may fed at a small cost as compared with some of the larger breeds. ey are of medium size and of a mottled plumage, black and white ermixed, the black predominating. Houdans are a crested variety. e crest of the cock is large, well fitted upon the crown of the head, ling backward upon the neck, and composed of feathers similar shape and texture to those of the hackle. The crest of the female large, compact, and regular, inclining backward in an unbroken ss. The Houdan has a small V-shaped comb, which rests against e front of the crest. A peculiarity of the breed is their having e toes, like the Dorkings; shanks and toes are of a pinkish-white lor, mottled or shaded with lead color or black.

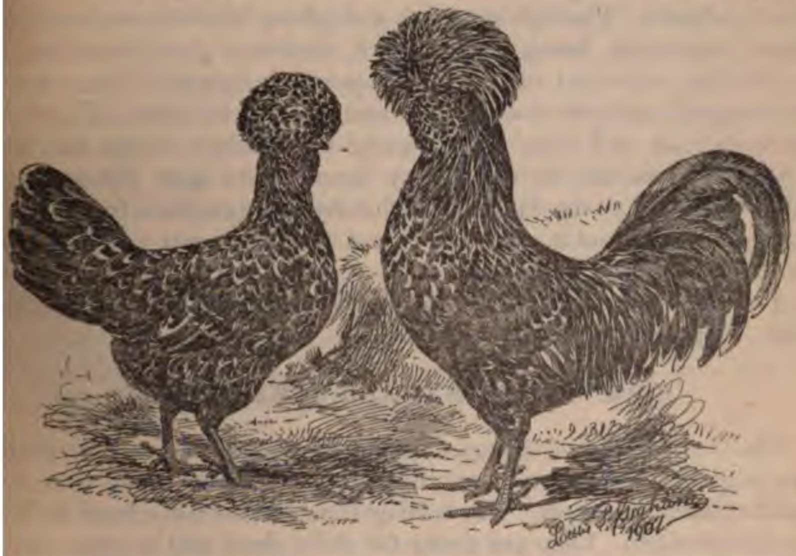

FIG. 18.—Pair of Houdans.

The standard weight of cocks is 7 pounds: hens, 6 pounds; cockels, 6 pounds; pullets, 5 pounds.

### CREVECŒURS.

This variety is not so generally known in this country as the oudans, but in France, their native country, they are bred extenely for market purposes. They are considered of superior quality r the table, their flesh being white and delicately flavored. They are of gentle disposition and do well in confinement. They have weak constitutions and require extra care and attention. As layers they are only fair, and are nonsitters. They are a crested variety, have a leaf comb like the letter V in shape, and in plumage are a rich, glossy black throughout.

The standard weight of cocks is 8 pounds; hens, 7 pounds; cockerels, 7 pounds; pullets, 6 pounds.

### LA FLÈCHE.

La Flèche fowls differ in character from the other two varieties of French poultry mentioned. Houdans and Crevecœurs are more compactly built than La Flèche, the latter being tall and rather gaunt looking, and in style and character denote the preponderance of Spanish blood. Their plumage is a rich, glossy black throughout. The comb is peculiar, being V-shaped, of moderate size, branching and antler-like, somewhat like two horns pointing upward. The birds are of extremely delicate constitution and difficult to raise. The flesh is more delicate and juicy than that of any variety except the Game. They are moderate layers of very large, white eggs, but are by no means so good as the Spanish in this respect; as table fowl they are superior, but do not mature early—not nearly so early as the Houdans or the Crevecœurs.

The standard weight of cocks is 8½ pounds; hens, 7½ pounds; cockerels, 7½ pounds; pullets, 6½ pounds.

### CLASS VIII—GAMES AND GAME BANTAMS.

The Game is one of the most interesting breeds of domestic poultry. Its origin and history are seemingly linked with all topics concerning poultry and its origin. For a long time Games have been favorites in this country. They are noted for their vigor and courage, having formerly been bred for fighting. By careful selection in breeding for many generations they have been brought to a high state of perfection. The beauty of an exhibition Game is much praised in this and other countries and the pens are generally filled at the shows. They are sought after and courted by fanciers, and as ornamental fowls they have few equals in the number of their admirers. The practical qualities of the Game have never been demonstrated with accuracy, their tall figures standing in the way of popularity and general usefulness. It should not be understood that they are unprofitable to keep, but rather not a fowl for farm purposes. They are usually good layers and excellent table fowl, their meat being fine-grained, tender, and juicy. They are splendid sitters and mothers. Their tall, commanding, and striking figures are decided contrasts to those of other poultry, and afford a diversion to admirers of fine poultry. The varieties are Black-breasted Red, Brown Red, Golden and Silver Duckwing, Red Pyle, White, Black, and Birchen.

### BLACK-BREASTED RED GAMES.

The history of the Black-breasted Red Game dates from the most remote times. They always breed uniformly and invariably alike in color, this uniformity being also observed in the Bantams of this name. The color of the head of the cock is a bright orange; hackle and saddle, light orange; breast, body, and stern, black; shoulders, black; wing bows, red; coverts, black; tail feathers, sickles, and tail coverts, lustrous black; thighs, black; shanks and feet, willow. The head of the hen is golden brown; the hackle, light golden, the hackle feathers being striped with black down the center; the feathers of the body are ashy brown; the tail, black or dark brown, the upper feathers being penciled with light brown.

The head of the cock is long, and the neck slim and long; breast, broad; back, straight and sloping to the tail; body, hard and compact; wings, large; tail, small and closely folded, with few sickles and fine narrow hangers; thigh, long and well developed; shank, long and smooth; toes, long and straight. The hen is about the same shape as the cock, and the carriage of both is bold and upright.

The Black-breasted Red Game is an excellent table fowl and a moderate layer of medium-sized eggs of rich flavor. The chicks require much care, as their constitutions are weakened from too close breeding for ornamental purposes.

### BROWN RED GAMES.

The Brown Red Game differs from the Black-breasted Red Game in the color of the head. The face is dark purple; beak, black; wattles, comb, and ear lobes, black or dark purple; head of cock, orange; hackle, lemon colored, with a dark stripe down the center of each feather; back, lemon; saddle, lemon, striped like hackle; breast, black, laced with lemon; shoulders, black; wing bows, lemon, and coverts glossy black; tail, lustrous black; shanks and feet, dark willow or nearly black.

### GOLDEN AND SILVER DUCKWING GAMES.

The Golden and Silver Duckwing Games are similar in markings, the main difference being that the Silver Duckwing cock (fig. 19) is silvery white where the Golden Duckwing is golden or straw color. In both varieties the face, comb, wattles, and ear lobes are red; beak, horn; breast, tail, and thighs, black; shanks and feet, willow. In the Golden the head of the cock is straw color; back, golden; wing bows, golden, the wing coverts forming a distinct black bar across the wing. These points, except the wing coverts, which are black, are white in the Silver Duckwing.

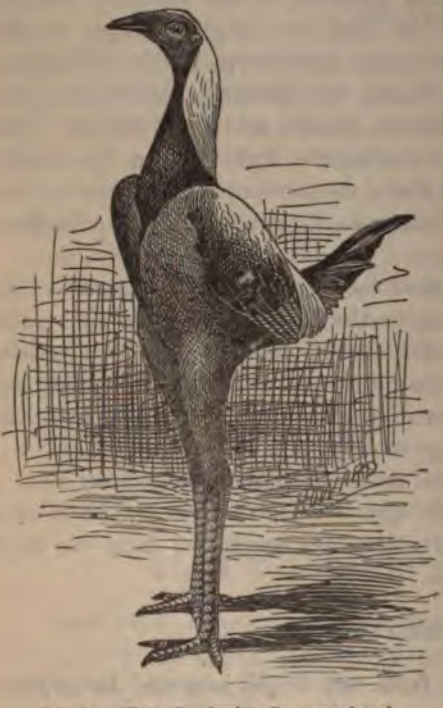

FIG. 19.—Silver Duckwing Game cockerel.

### RED PYLE GAMES.

The plumage of the head and hackle of the Red Pyle Game cock varies from bright orange to light red; the back is red or crimson; breast, white; body, white; shoulders and wing fronts, white; wing bows, red or crimson; wing coverts, white, forming a distinct bar across the wing; tail and tail coverts white. The head of hen golden red; hackle, white, edged with gold; back, white; breast, salmon; wings, white; tail, white. Shanks and feet of both cock and hen are yellow or willow—yellow preferred.

### WHITE AND BLACK GAMES.

These two varieties differ only in color from the others of their breed. The plumage of the White Game is a pure, spotless white; beak, shanks, and feet, yellow; comb, wattles, and ear lobes, red. The Black Game is a lustrous black in plumage; beak, shanks, and feet, black; comb, wattles, and ear lobes, deep red.

### BIRCHEN GAMES.

Birchen Games are silvery white and black; head and back are silvery white; hackle and saddle of cock are silvery white, with a narrow dark or black stripe in center of each hackle and saddle feather; breast, black, each feather laced with silvery white; wing coverts, glossy black; tail and thighs, black; shanks and feet, dark willow or black; comb, wattles, and ear lobes, dark purple or black. The plumage of the hen is black, except that of the head, which is silvery white, and of the hackle, which is silvery white with a dark stripe down the center of each feather, and of the breast, the feathers of which are black, evenly laced with silvery white.

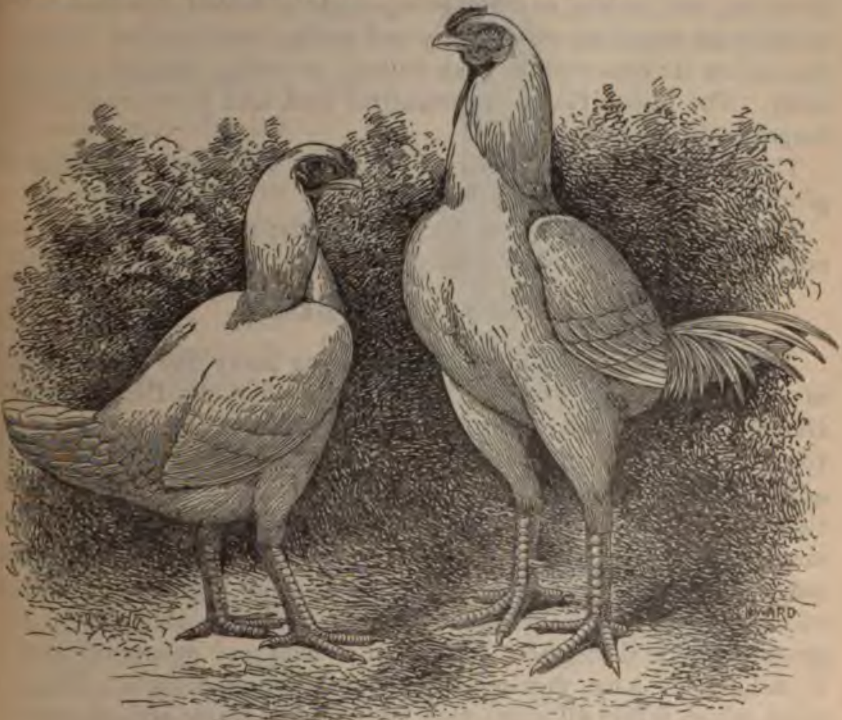

FIG. 20.—Pair of White Indian Games.

### GAME BANTAMS.

Game Bantams are diminutive representatives of the Games. The color of plumage, markings, and shape must correspond with these features in the Game which bears its name, the diminutive size being the only distinguishing feature between the two. The cocks average about 22 ounces in weight, the hens 20 ounces.

## CLASS IX—ORIENTAL GAMES AND BANTAMS.

### CORNISH AND WHITE INDIAN GAMES.

The Indian Game (fig. 20) has many fine qualities to recommend it to the breeder, and for many years past has been a popular fowl. In plumage the Cornish Indian male is green-black intermixed with red and bay. The plumage of the hen should be a combination of bay and black throughout.

The breast is very wide, round, and prominent, the thighs are well rounded, and thick and meaty next the body; the shanks are very stout, smoothly scaled, and yellow in color; the back toe should be almost flat on the ground; the tail close and hard, carried at slight elevation, and sickles narrow; wings tightly folded, the ends of the secondaries rounding off abruptly and resting close against the tail or just below it; eyes yellow, beak yellow, or yellow striped with horn color. The Indian Game is a beautiful bird, and its every movement bespeaks its high breeding.

The White variety is identical with the Cornish except that the plumage should be pure white.

The standard weight of cocks is 9 pounds; hens, 6½ pounds; cockerels, 7½ pounds; pullets, 5½ pounds.

### BLACK SUMATRA GAMES.

Although a beautiful bird and possessing many fine points worthy of the consideration of the fancier and breeder, the Black Sumatra Game is little known. It is gentle of disposition and attentive to its young. There is considerable comment against the Sumatras on account of the long flowing tail and apparent lack of fighting qualities; but as to this those who have witnessed their defense of their mates and young differ. They may be slow in opening a conflict, but when occasion demands, no bird can show a greater amount of staying power than the Sumatras. In plumage they are a rich greenish black throughout. The tail is long and drooping, with an abundance of long, flowing sickle feathers and coverts. This is a point which severs all connection with the Pit Game and places them in the front rank of the ornamental breeds.

### MALAY GAMES.

The Malays (fig. 21) have never been popular in this country and are bred for exhibition only, not possessing qualities for practical purposes. They are of medium size, and in carriage are particularly upright and powerful looking. Their plumage is very close, and red or maroon and black. The body tapers from the broad shoulders to the tail, which droops almost in a straight line with the back. The thighs are long and powerful. A striking feature of the Malay is the head. It is long, the crown over the eyes being heavy and projecting, giving the bird a cruel and fierce expression; the neck is long and scanty of hackle; the skin of the throat is a bright red, and the scantiness of the plumage causes the red to show distinctly. This is a characteristic of the breed. The wattles and ear lobes are slight in development; the shanks and toes are bright yellow. The Malays are large and hardy, and are used for crossing with other breeds to infuse vigor and size. In disposition they are reputed to be very savage, and in battle often literally tear their opponents to pieces.

The standard weight of cocks is 9 pounds; hens, 7 pounds; cockerels, 7 pounds; pullets, 5 pounds.

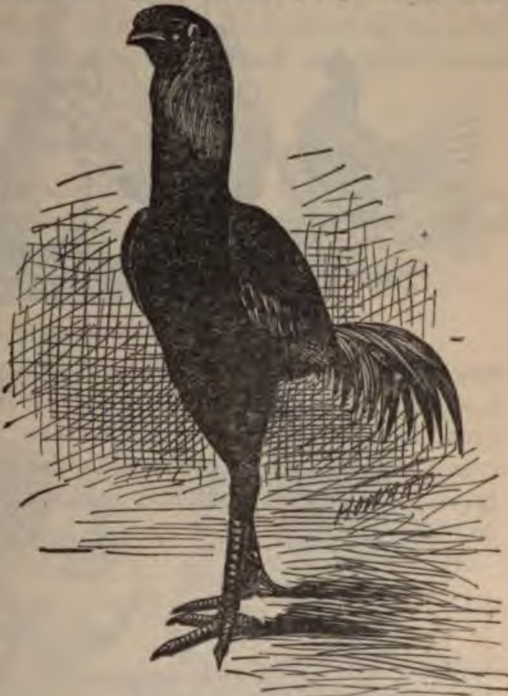

FIG. 21.—Malay Game cock.

### MALAY BANTAMS.

In shape and color the Black-breasted Red Malay Bantam should be the same as the standard size Malay.

The standard weight of cocks is 26 ounces; hens, 24 ounces; cockerels, 24 ounces; pullets, 22 ounces.

## CLASS X—ORNAMENTAL BANTAMS.

### SEBRIGHT BANTAMS.

Bantams are purely ornamental poultry, and are kept for pleasure exclusively, though some contend they are profitable for eggs and table. This is hardly reasonable to suppose, as their diminutive size and small eggs would hardly pay for their keep other than for fancy purposes. The Golden and Silver (fig. 22) Sebright Bantams were originated in the early part of the last century by crossing a common Bantam with a Polish fowl and breeding the cross to a hen-feathered bantam. After many years of successful breeding beautiful birds have been produced which breed true to type.

The plumage of the bird is rich golden yellow in the Golden variety, and silvery white in the Silver variety. The feathers of each variety are distinctly laced with a narrow edging of black. The head is small and surmounted by a bright-red rose comb in the male and a purplish-red comb in the female; the neck is well arched and hen feathered; the back is short and free from saddle feathers; the breast is round and full and the body compact; the wings ar and carried low, but not so low as to conceal the hocks; the are short, and the shanks and toes are slaty blue in color. Th weigh about 26 ounces, the hens about 22 ounces.

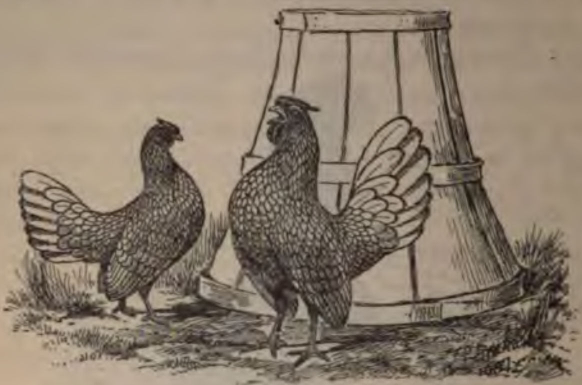

FIG. 22.—Pair of Silver Sebright Bantams.

### ROSE-COMB TAMS.

Rose-comb tams are mi Hamburgs. are two v the Black ( and the Whit cock has a round head; and slightly beak; large inent bright rose comb, square in front, fitting firmly on the head and en a spike with a slight upward curve; flat, closely fitting ear broad, thin, and well-rounded wattles; neck small at the he creasing in size as it approaches the shoulders, nicely arch carried well back; abundant hackle of good length, sweepi the shoulders, with long and plentiful saddle feathers; full round breast, carried prominently forward; plump, compact, and symmetrical body; wings large, the points carried low, the secondaries slightly expanded; full expanded tail carried at an angle of 40° from the horizontal, and furnished with long curvin and coverts; short thighs, and short, clean, tapering shanks.

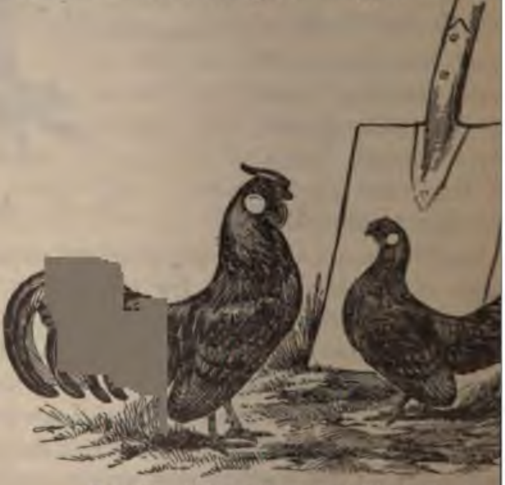

FIG. 23.—Pair of Rose-comb Black Bantam

The head of the hen should be small and neatly round ght and full; comb of the same character as the cock's, but aller: flat, smooth ear lobes; small wattles; the neck should be ort, tapering, and carried well back; the back short; the breast ll and prominent; the body compact; wings large; tail full and panded; thighs short, and shanks short and tapering.

The plumage of the Rose-comb Black Bantam is lustrous black, d of the White, pure white. The beak of the Black is black, or rk horn color; of the White, white. The ear lobes of both va- ties are pure white. The shanks of the Black are dark, leaden ue, or black; of the White, white.

### BOOTED WHITE BANTAMS.

Booted White Bantams are distinguished, as their name implies, heavily feathered or booted shanks. They have small heads and edium-sized ngle combs. he hackle feath- s are long and rtly cover the oulders; the ings are large nd slightly rooping; the il is upright, ith long sickles nd abundant overts; thighs ong, and covered ith long, stiff eathers or vul- re hocks, which early reach the round; toes and anks white. The plumage is pure and white.

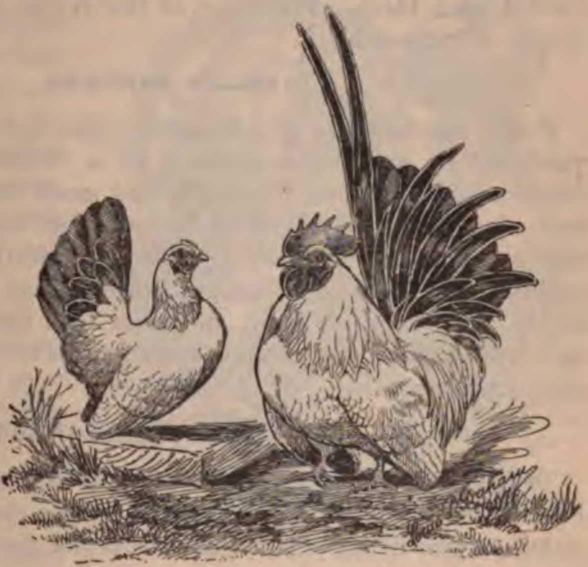

FIG. 24.—Pair of Black-tailed Japanese Bantams.

### BRAHMA BANTAMS.

Brahma Bantams should conform in miniature in both color and ape to the larger Brahmas.

Standard weight of cocks is 30 ounces; hens, 26 ounces; cockerels, ounces; pullets, 24 ounces.

### COCHIN BANTAMS.

Cochin Bantams are in both color and shape the same as their rger ancestors. The cock weighs about 30 ounces, the hen 26 ounces.

## JAPANESE BANTAMS.

The striking beauty and peculiar-shaped tails of the Black Japanese Bantams (fig. 24) make them great favorites and them in the front rank of the Bantam class. They are whi cepting the tail and wings. The tail is black; the sickles and are black, edged with white. The wings are large and long drooping points; the color of the primaries and secondaries i slate or black, edged with white. When the wing is folded it only white. The tail is expanded and carried in an upright p almost touching the back of the head; sickles, long and s curved. The shanks are free from feathers and are yellow in

The White and Black Japanese Bantams are the same in si shape as the Black-tailed Japanese. The beak, shanks, and the White are yellow, and those of the Black are yellow, or shaded with black. The color of the White is pure white; Black, a lustrous black.

## POLISH BANTAMS.

Polish Bantams are of American origin, and appeared abou produced by an accidental cross of a White Polish cock common hen. At first the chicks had small crests and the pl was often disfigured by foul feathers, but under careful br the color has been established, so that foul feathers no longer and the crests have been nearly doubled in size. They were ad to the standard in 1879–80, and since then they have been d nated throughout the country, although perfect specimens are comparatively rare.

## CLASS XI—MISCELLANEOUS.

The Standard recognizes some varieties of poultry which are ornamental in character and purpose. They can not be consid either prolific in egg production or superior for table purposes

## SILKIES.

Silkies are not extensively bred in this country, but in Engl very popular. Their soft, webless feathers, when in prime co are exceedingly loose and fluffy, standing out from the bod directions, giving the fowl the appearance of a large bird, whi weight does not justify. The cocks weigh from 2½ to 4 pound the weight of the hens is from 2 to 2½ pounds.

The birds are of rather square, compact, Cochin build, cres cock's crest running back horizontally, while the hen's is gl five toed; feather legged; comb, lumpy in appearance and da ple in color; ear lobes, purple tinged with white; skin, vio proaching black, the covering of the bones being of the sam shanks, dark leaden blue or black; plumage, white and downy. Silkies lay small eggs of a pale buff color, and lay 10 to 25 before wanting to sit. They make excellent mothers, and are very valuable to hatch and rear the tender little ones of the more delicate varieties.

### SULTANS.

Sultans (fig. 25) were exported from Turkey into England about 1854, and did not reach America till some years later. They might with propriety be classed with the Polish, considering the characteristics which they possess. A compact crest surmounts the head and they are full bearded. Two small spikes constitute the comb. The neck hackle is abundant. The legs are heavily feathered and booted, and hocks vultured. They possess a fifth toe. The tail is full and erect, and in the cock is abundantly furnished with sickles. While their beauty is their chief recommendation, they lay claim to modest usefulness, but only as layers, being too small for table fowls. They thrive well on a limited range or in confinement, and owing to their docility make excellent pets. The color of plumage is pure white throughout.

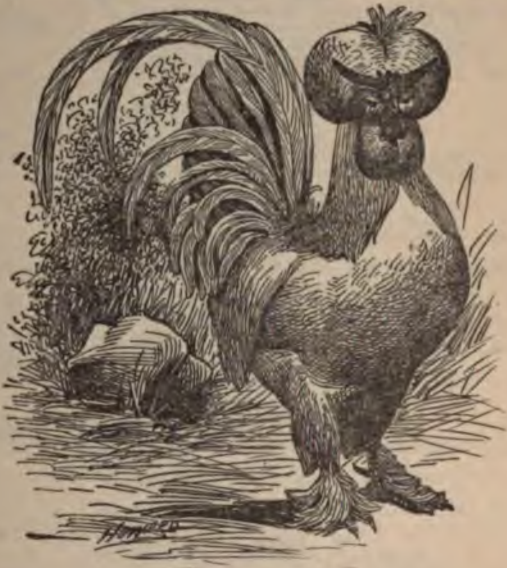

Fig. 25.—Sultan cock.

### FRIZZLES.

Frizzles are the most grotesque members of the poultry family. They derive their name from the peculiar manner in which their feathers curve upward and backward at the ends, as if in defiance of nature's laws. This curving is most conspicuous in the hackle and saddle feathers. As these birds vary in color, there is no rule for judging their plumage except that it must have the peculiar upward curve. The color, however, should be solid; black, white, red, and bay being admissible, provided that the colors match when birds are shown in pairs, trios, or pens.

## NOTE.

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FARMERS' BULLETIN 52.

# HE SUGAR BEET:

## CULTURE, SEED DEVELOPMENT, MANUFACTURE, AND STATISTICS.

BY

H. W. WILEY,

*hief of the Bureau of Chemistry, and formerly Director of the Department Sugar Beet Experiment Station in Nebraska.*

[Third Revised Edition, August, 1908.]

By A. HUGH BRYAN,

*Sugar Laboratory, Bureau of Chemistry.*

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1908.

# LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Chemistry,
*Washington, D. C., August 17, 190*

Sir: I have the honor to transmit for your approval the third revision of Fa
lletin No. 52, on the sugar beet, prepared by Mr. A. H. Bryan, chief of the
oratory, who has had practical experience in the beet-sugar industry. This
in was last revised in 1901, having been originally issued in 1897, and first rev
1899. Extensive changes have been made in the text that the most recent
es in sugar-beet culture might be given; references to the work of the Bure
tomology and Plant Industry, bearing on diseases of the sugar beet, pests attac
and the development of the single-germ seed have been inserted, and the stati
ve been brought up to date. It is hoped that the bulletin in its revised form
ve as useful as its predecessors to those interested in the extension of this indu
demand for this information having continued during the past nine years.

Respectfully,

H. W. Wiley, Chi

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# THE SUGAR BEET.

## INTRODUCTION.

ccessful growing of sugar beets is an art that one acquires
ce. The farmer who has made a success of raising other
quite often fail at first in this one, as the methods of cul-
rdinary crops do not apply in the case of sugar beets. Cer-
tions for the preparation of the soil, the planting, thinning,
esting must be followed in beet culture. Although it is
o raise sugar beets with little regard to these directions,
op will usually fail to pay for itself either because the yield
ll or the sugar content of the beets too low to meet factory
nts. In commercial beet growing, therefore, carelessness
kly to failure, while careful regard for details spells success.
omes at first from following the advice of successful growers,
it may be augmented by practical experience. Certain
can be practiced, but they should never consist in planting
quantity of seed than is prescribed, nor in locating the beet
oor land.

manufacture of sugar from the beet, the farmer plays an
part by supplying beets in an adequate quantity and of a
ity; but beyond that he can hardly hope to enter the field.
ifacture of beet sugar is an industry entirely distinct from
e, and can only be successfully accomplished by the invest-
arge capital and the employment of skilled artisans. From
e of the process it is quite improbable that any simple
f home manufacture of beet sugar will ever prove commer-
cessful. The juice of the beet is extracted with difficulty.
s considerable quantities of mineral salts and organic sub-
hich render the crude sugar and molasses therefrom unpala-
mple processes for the extraction of the juice can at best
ly 60 to 70 per cent of the sugar which the beet contains, and
centage of loss is incurred which at the very outset renders
ble for a home apparatus to compete with a large factory.
r, for the reasons given above, can not be used in the raw
s the case with the products derived from the sugar cane,
and the maple tree. The refining of the sugar requires a
tlay for machinery and a high degree of supervisory skill.
, therefore, be accomplished upon the farm.

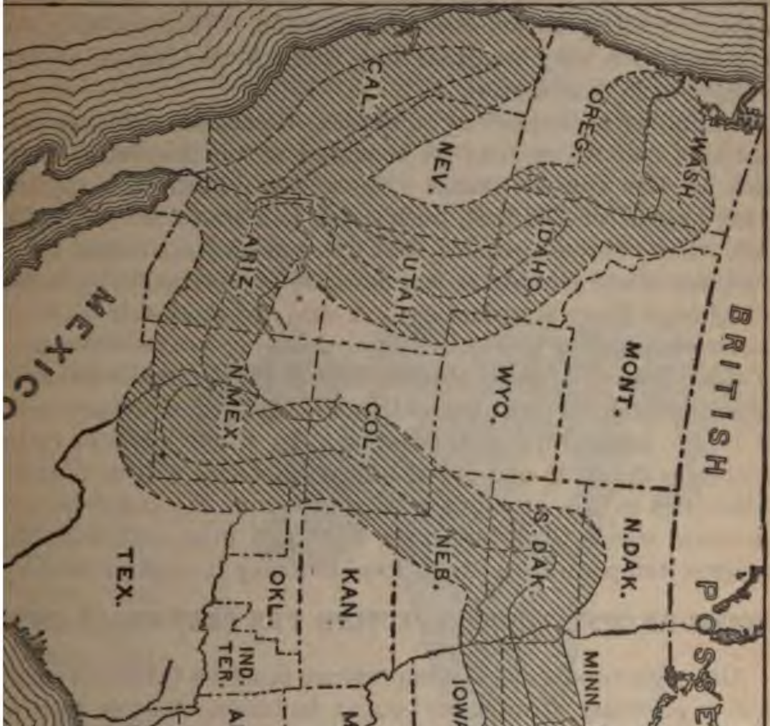
The beet-sugar industry offers a great opportunity for the pr ble extension and diversification of agricultural industries in country. The sugar beet is proving a profitable crop for the far not only in old settled areas where it must compete with a larg of established crops, but in the newly developed regions of the where its adaption to intensive farming makes it a favorite crop culture under irrigation. Its influence in developing stock bree feeding, and dairy industries is attracting the favorable attenti farmers interested in these pursuits. The rapid extension of industry during the past few years shows that its value is ga recognition; and there appears to be no valid reason why this e sion should not continue until all the sugar consumed in the U States is made from crops grown by American farmers.

## TEMPERATURE CONDITIONS AFFECTING THE BEET-SUG INDUSTRY.

Experience has shown that the sugar beet reaches its highest opment in north temperate latitudes. So far as the producti beets with high tonnage is concerned, it is found that this c accomplished far to the south, but beets grown there are, on the less rich in sugar and less suitable for the manufacture of sugar those grown farther north. It must be remembered, however, the expressions north and south do not refer to any absolute pa of latitude, but rather to isothermal lines, which in many cases widely from the parallels of latitude and in some cases cross almost at right angles.

**Theoretical beet-sugar belt.**—As a result of many years of c experimentation, it may be said that as far as temperature al concerned the sugar beet attains its greatest perfection in a zo varying width through the center of which passes the isotherma of 70° F. for the months of June, July, and August. This zon this country is shown in the accompanying map (fig. 1).

This isothermal line, for the United States, begins near the ci New York and passes up the Hudson River to Albany; thence tu westward, it runs near Syracuse and passes in a southwesterly tion, touching the shore of Lake Erie near Sandusky, Ohio; tu thence in a northwesterly direction, it enters Michigan and reach highest point in that State near Lansing; then going in a south erly direction, it enters the State of Indiana near South Bend, p through Michigan City, then in a northwesterly course cont through the cities of Chicago and Madison, reaching its highest near St. Paul, Minn.; thence it extends in a southwesterly dire until it enters the State of South Dakota, where it turns again n west and reaches its highest point in Dakota just above the forty parallel of latitude, where it crosses the Missouri River. The l line then turns almost due south, following very closely the ndred and first degree of longitude until it leaves the State of



ka near the northeast corner of Colorado; passing in a southly direction through Colorado, it reaches, at Pueblo, almost to the one hundred and fifth degree of west longitude, whence it in a slightly southeasterly direction into New Mexico, turns west, and crosses the one hundred and fifth degree of longit about the thirty-second degree of latitude. Then turning wes it passes in a very irregular line through the States of Cali Oregon, and Washington.

Extending a distance of 100 miles on each side of this isot line is a belt which may be regarded as the theoretical bee area of the United States. There are doubtless many lo lying outside of this belt, both north and south, in which th beet will be found to thrive; but this will be due to some exce qualities of the climate or soil and not to any favorable influ a higher or lower temperature. A study of the location of th factories operating to-day will show that only five factories are of these lines. A mean temperature of 70° F. in the summe ever, must not be regarded as the only element of temperatur is to be taken into consideration. In those localities wh winters come early and are of unusual severity will be found difficulties in the production of sugar from the sugar beet localities where the winters are light and mild, although th summer temperature of both localities may be represented by

## MOISTURE CONDITIONS AFFECTING THE BEET-SUGAR IND

Although conditions of temperature must be taken into co tion in selecting sites for beet-sugar factories, those of rainfa also be studied. The sugar beet requires a certain amount of m in order to produce its normal crop. This moisture must be either from precipitation in the usual way or from irrigation; the soil must be of that particular quality which will allow ranean moisture to reach the rootlets of the plants. Soil of th appears to exist in many localities in California, where beets ar almost without rain. The porous and sandy soils adjacent to of the Western rivers, such as the Arkansas River in eastern C and western Kansas, also appear to furnish a sufficient am subterranean moisture to produce a good crop in connection w rainfall, of which, however, but little is expected in those lo during the summer months. Where there is little subterranea ture, and where irrigation is not practicable, the culture of th beet should not be undertaken unless an average summer precip of 2 to 4 inches per month can be depended on. There are ma ditions of agriculture, however, under which the beet become independent of extremes of precipitation. The beet may thri very little rainfall or with a great deal, if properly cultivat suitable soil.

## GROWING BEETS ON IRRIGATED LANDS.

The experience of more than twenty years in California and eight years in Colorado has shown that the climatic data, regarded as of prime importance in beet culture in Europe, can not be regarded as rigidly applicable to this country. The successful growth of sugar beets in the arid regions of our country, with irrigation, has introduced a new factor into the science of beet meteorology. While the arid area on which beets can be grown without irrigation is probably confined almost exclusively to the coast valleys of California, the successful commercial production of sugar beets in Utah and Colorado has opened a new and extensive field. What has taken place in these States is being rapidly duplicated in Idaho; a beginning has been made in Montana, and the time is undoubtedly coming when beets will be grown in Wyoming and probably throughout the whole arid region.

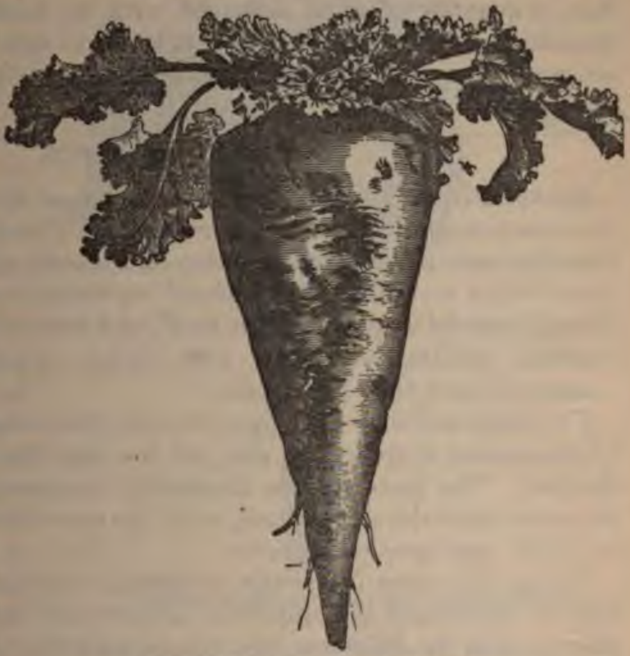


FIG. 2.—Kleinwanzlebener sugar beet.

The northern parts of our Eastern and Middle States and the States of Oregon and Washington have at least an equal chance for the successful production of beet sugar with the fields of Germany and France. The irrigable parts of the great Southwest have advantages of soil and climate which will enable them to enter into competition in the production of beet sugar. To be able to control the moisture of the soil is a matter of prime importance to the beet grower. In the arid region the time at which the beet matures can be controlled by withholding the water. Furthermore, there is no danger of loss due to second growth, so easily induced by late warm autumnal rains.

The high cost of good irrigation renders it imperative that the areas under culture be devoted to a crop which is capable of producing a

profit of from $10 to $20 per acre can be secured, from $
per acre can be paid for the land. It is estimated
80,000,000 acres of land in the arid regions of the United
eventually be irrigated, being nearly one-fifth of the tot
this area perhaps 10 per cent is capable of easy and speed
One million acres planted to beets would yield, under in
ture, a quantity of sugar sufficient, with the Louisiana
domestic consumption. There is nowhere in sight a mor
prospect for agricultural development than in the product
beets on irrigated lands.

## VARIETIES OF BEETS.

Botanically all kinds of sugar beets are of the same
the common garden beet (*Beta vulgaris*). The differenc
varieties have arisen from selection and breeding. Cert
peculiarities resulting from natural variations or muta
through careful selection, been *fixed*, and pure strains h
superior qualities associated with certain distinguishi
characters have been developed.

The shape and size of the beet, its color, the character of
whether erect or spreading, etc., are the most frequent m
tinction. The beets are also frequently designated by t
those who have developed them, or by the name of the tow
in which they have been grown.

Among the more frequently occurring varieties grown
may be mentioned the Improved Kleinwanzlebener, the
lebener, and the Vilmorin, the two latter being most wi
in this country. Sugar manufacturers prefer those vari
yield a high percentage of sugar, since the juices are pu

such a high state of perfection as to make the least degree of laxity in its treatment exceedingly dangerous to its qualities.

The best beet for general cultivation is probably the Kleinwanzlebener, which seems now to have a wider cultivation in this country than any other variety. The general character of this beet is shown by figure 2. It has a conical root, straight and even, quite large at the head and rapidly tapering, and is distinguished from the Improved Vilmorin by its brighter color and its lighter-colored leaves, which are beautifully undulating or scalloped about the edges. Coming from a cross in which the Improved Vilmorin entered largely, the Kleinwanzlebener is to-day a fixed variety and is equally well produced in France and Germany. It succeeds in soil of an alluvial nature and average richness and on level plateaus. In soils very rich in humus it ripens poorly and loses much of its richness. Like the Improved Vilmorin, toward the end of the growing season its leaves are completely spread. Under those conditions of culture where the Improved Vilmorin gives from 12 to 16 tons per acre, the Kleinwanzlebener gives from 14 to 18 tons; and from these beets 13 to 18 per cent of sugar can be obtained.

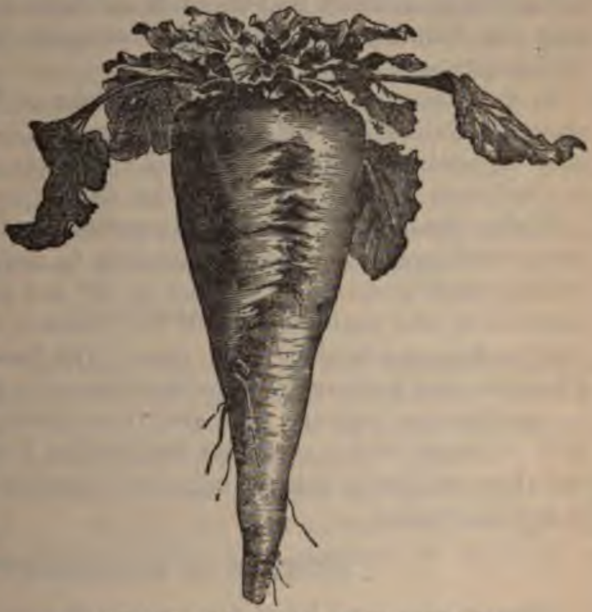


FIG. 3.—White Improved Vilmorin sugar beet.

The other general type, the Vilmorin, is illustrated in figure 3. This beet is the result of thirty-five years of methodic and persevering selection based upon the lines to be indicated hereafter. In regard to its preservation, it is recognized that it holds its sugar content as well as any other variety. In those factories in Germany and France in which sugar is manufactured from the Improved Vilmorin in connection with other varieties it is the custom to reserve this variety for the end of the season and to work up the less reliable beets at an earlier date. It is also said to resist better than any other variety the unfavorable influence of certain characters of soil and of certain manures. In black soils, rich in organic matter, it gives great results, while most other varieties of beets become watery or saline in excess. Excessive quantities of nitrogenous fertilizers, which are carefully excluded from ordinary varieties, can be applied with safety to the Improved Vilmorin; a great number of experiments have shown that this can be done without serious deterioration in the quality of the beet and with a considerable increase in weight. However, experiments with Kleinwanzlebener beets show that they are also susceptible to the influence of such fertilizers, as is shown by a gain in tonnage when fertilized. From thousands of analyses it has been established that about 16 per cent of sugar can be obtained with the Vilmorin and that under favorable conditions from 12 to 16 tons per acre can be raised.

In this country considerable quantities of beet seed have been grown at Fairfield, Wash., and also by the Utah-Idaho Sugar Company in Utah and Idaho chiefly, in the latter case, for its own use. In California and Michigan also some seed is produced.

Within the last four years the Department of Agriculture has been doing considerable work in endeavoring to develop a strain of beets bearing single-germ seed balls (see p. 30) and in growing seed better adapted to the requirements of this country. Considerable progress has been made along these lines. The farmer growing beets for a factory does not have to consider these points to any great extent, as the factories buy the seed and then furnish it to their growers. It is of prime importance that the factory purchase the best seed, and they are better able to judge as to the kind of seed desired and to test its vitality.

## CULTURE OF SUGAR BEETS.

Farmers who raise beets for a sugar factory are not left entirely to their own resources in growing the crop. They enter into a contract with the factory management which outlines the methods to be employed. Then the factory employs an agricultural superintendent and a corps of assistants whose duty it is to go among the growers giving instructions and suggestions regarding the selection and preparation of the soil, planting, cultivation, time of harvesting, etc. These men are of course well informed on all phases of beet culture, and they are usually able to make valuable suggestions in regard to the cultivation of other crops grown in rotation with beets. Their instructions and influence, therefore, tend to improve the farm practice of communities in which sugar beets are grown.

## SELECTION OF SOIL.

e sugar beet does not require a particular kind of soil for its er production. In general, soils are described for practical pur- as clayey, sandy, loamy, or alluvial soils; all of these soils will uce beets. The black prairie soils also have been found, with er cultivation, to produce excellent beets. Perhaps the best may be described as a sandy loam, a soil in which there is a y equilibrium of organic matter, clay, and sand.

w land should not be selected to grow sugar beets, for the crop t a good reclaimer of soils; and especially to be avoided is new containing decaying vegetable matter, which produces only growth with low sugar content. Preferably the most produc- land on the farm should be used, such a soil as will yield a good of Indian corn, wheat, or potatoes. The soil should neither compact as to interfere with cultivation to a depth of 10 or 12 s nor have a tendency to bake hard. It may contain some i, as sugar beets are not especially susceptible to injury from constituent. The soil should be reasonably level, but it should be well drained. Natural drainage on level soil being somewhat ient, tile drainage may be practiced with advantage.

## FERTILIZATION.

appily, in most American soils there is still sufficient natural lity to produce a good crop of sugar beets; whereas in the soils urope, where sugar beets have been grown for years, the farmers depend on fertilizers to insure a remunerative crop.

e principles of fertilization depend upon the fact that a soil ld have returned to it all that the harvest has removed, and an oductive soil be supplied with those elements in which it is ient.

he soil ingredients most essential for the successful production gar beets are nitrogen, phosphoric acid, potash, and lime.

he following are the quantities of these constituents in 1,000 nds of beet roots and in an equal quantity of beet leaves, as deter- ed by numerous analyses:

| Constituents. | In 1,000 pounds of roots. | In 1,000 pounds of leaves. |
|---|---|---|
| | *Pounds.* | *Pounds.* |
| h | 3.3 | 6.5 |
| horic acid | 0.8 | 1.3 |
| gen | 1.6 | 3.9 |
| ash | 7.1 | 18.1 |

will be seen from the foregoing table that, for equal weights, leaves make a heavier drain on the plant-food elements of the

soil than do the roots. The disposition to be made of the leav
therefore a matter of considerable importance. By leaving them
the land the plant-food elements which they contain will be retur
to the soil. If they are removed for feeding, the need for applicat
of commercial fertilizers is increased. The leaves may, howeve
fed and the resulting manure may be returned to the soil with
material loss of these fertilizing constituents; or in some cases st
may be turned into the beet fields to feed on the tops and le
remaining on the ground after the harvest is completed.

Most soils contain a sufficient quantity of lime, although th
are some in which the supply of lime is naturally deficient;
such soils would be benefited by an application of land plas
burned lime, phosphatic slags, or ground shells. Phosphoric
and potash are supplied in the form of ordinary commercial fe
lizers—the phosphorus as ground bone, superphosphate, or basic s
and the potash may be supplied in the form of muriate or sulph
of potash or as kainit.

Nitrogen may be supplied in the form in which it exists in gro
bone, or from the refuse of the slaughterhouses in the form of d
blood and tankage, or as cotton-seed meal or oil cake, or as nit
of soda, sulphate of ammonia, etc.

Barnyard manure offers a ready means for fertilizing the soil,
one which every farmer can employ. By its use, humus is adde
the soil as well as small percentages of potash, phosphoric acid,
nitrogen. There is a great difference of opinion as to the best t
and method for applying it to beet land. In general, howeve
should be applied, in a well-rotted condition, in the autumn be
the ground is plowed. The quantity per acre depends, of course
the fertility of the soil; but in any case it is not best to apply a
heavy dressing. With poor soils it is best to apply the manure
several years in succession, rather than to apply enough at onc
bring it up to the required state of fertility. Too copious an ap
cation of manure is apt to produce overgrowth in the beets, wh
makes them ill suited to the manufacture of sugar. If the ma
be applied in an unrotted condition it is apt to seriously injure
crop in case of dry weather.

As to the relation which the quantity of material returned to
soil should bear to the quantity abstracted by the beet, it may
said in general that it is desirable to return as much nitrogen, f
one and a quarter to one and a half times as much potash, and
and a half times as much phosphoric acid as have been removed
the roots. Greater additions of potash and phosphoric acid h
no disadvantageous effects upon the crop. But it must not
expected, on the other hand, that increasing fertilization, especi

with potash, will produce proportionately increasing crops, as has been asserted by some.

As regards the use of nitrate of soda for fertilization, if applied late to the beet crop, it prevents its ripening, thereby lowering the sugar content. It is best applied early and in small quantities. Heavy applications are thought to injure the beet for manufacturing purposes.

## CROP ROTATION.

Every farmer should understand that he can not continuously grow any crop on the same ground and secure maximum results. Many try to do this, but they do it to their own loss and the depletion of the soil.

One of the great objects of crop rotation is to bring about and maintain an equilibrium of soil constituents and conditions. The best rotation is the one in which the method of culture and action of the plant each year leave the soil in the best condition for the following crop. Beets do best after alfalfa, corn, or small grains.

A good scheme of rotation is, first, wheat; then beets; then clover for two years, the last crop being plowed under; then potatoes, wheat, and beets in the order mentioned. If alfalfa can be grown, it should be included in the rotation of crops. Also in some sections potatoes do well in the rotation. By this method, and a judicious use of stable manure and commercial fertilizers, the fertility of the soil can be maintained and even increased. Beets do well after small grain crops, because these, being harvested early, leave the ground ready for late autumn plowing, an important point in successful beet culture.

## PREPARATION OF THE LAND FOR PLANTING.

The field in which beets are to be planted should be selected and plowed in the late autumn to the depth of at least 9 inches. As a rule the plow in each furrow should be followed by a subsoiler, which will loosen the soil to the depth of 6 or 7 inches more. A convenient subsoil plow is shown in figure 4. Each field to be planted in beets should thus have the soil prepared by thoroughly loosening it to the depth of from 15 to 18 inches. The land, being exposed through the winter, becomes quite mellowed, and in the spring can in many cases be prepared for planting by thoroughly cultivating the surface of the soil until it is reduced to perfect tilth. The large cultivator shown in figure 5 can be conveniently used for this purpose, followed when necessary by a harrow and roller. Too much can not be said of the importance of correct preparation of the ground before seeding, as on this condition the crop depends to a large extent. The seed bed should be uniformly well pulverized. It is desirable, however, that

## PLANTING THE SEED.

Hand planting of the seed may be practiced when a very small plat to be put in beets, but where a field embracing an acre or more is be planted it is not convenient. In such cases planting by drill is est. Almost any garden drill can be adapted to use with beet seed. pecial drills for sugar-beet seed are made by many manufacturers f agricultural implements. In planting by drill it is necessary to se from 15 to 20 pounds of seed per acre; in planting by hand from 0 to 15 pounds will be found sufficient.

A very convenient hand drill, which is especially fitted with a beet-eed dropping apparatus, is shown in figure 6. This machine marks the row, excavates the furrow, drops the seed at any required distance, and covers it.

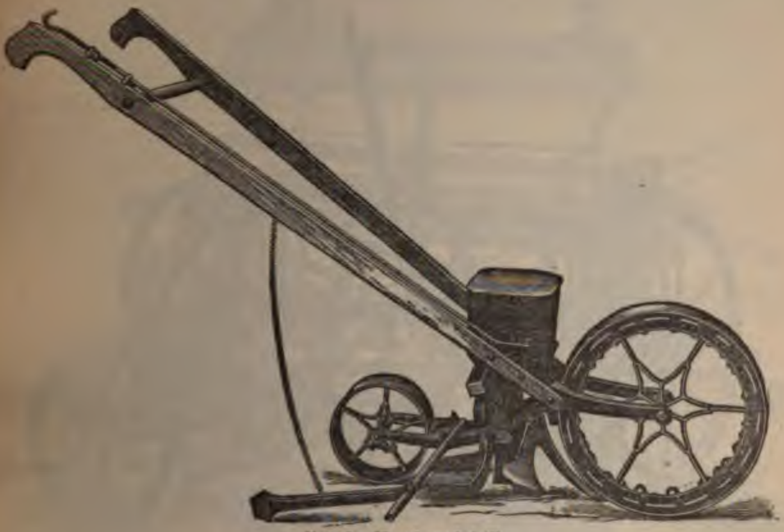


FIG. 6.—Hand seed drill.

The beets should be covered to a depth of one-half inch to 2 inches, according to the state of the soil. If the soil be moist and in excellent condition, the beet seed should not be covered more than half an inch. If, on the other hand, the soil be very dry and early rains are not probable, the seed should be covered to a depth of 2 inches.

In the matter of space between rows there is considerable variation. In some cases the rows are made only 16 inches apart, and in others as wide as 28 inches. In recent years the tendency has been to increase rather than diminish the distance, though much depends on the soil and local conditions. It is argued by many that the greater ease and economy of culture with the wider rows outweigh the increased yields per acre which may be secured in the narrower rows.

each portion of the field to be planted should be thoroughly prepared immediately before the planting takes place. For instance, if the planting is to be made on a given day, the soil should be thoroughly prepared on the previous day. Thus all weeds and grasses which have started to grow are killed, and the beets have an even chance with the weeds for growth. If, on the other hand, the soil be prepared a week or even a few days before planting, the weeds and grasses get a good start, and it is difficult to free the beets therefrom. In case the ground has to stand any time before seeding after being prepared, it should be constantly and thoroughly cultivated.

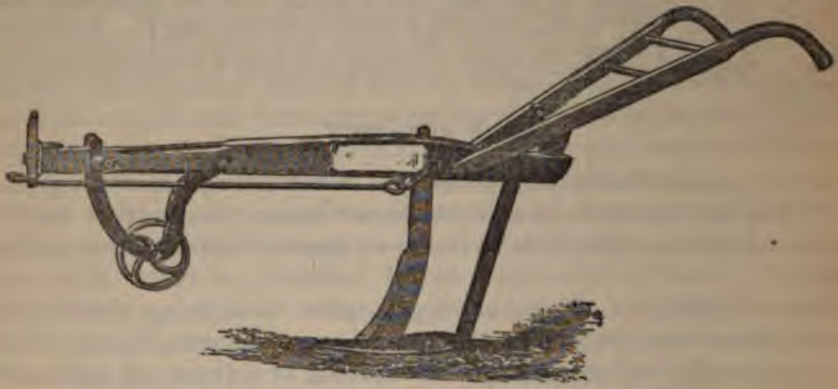


FIG. 4.—Subsoil plow.

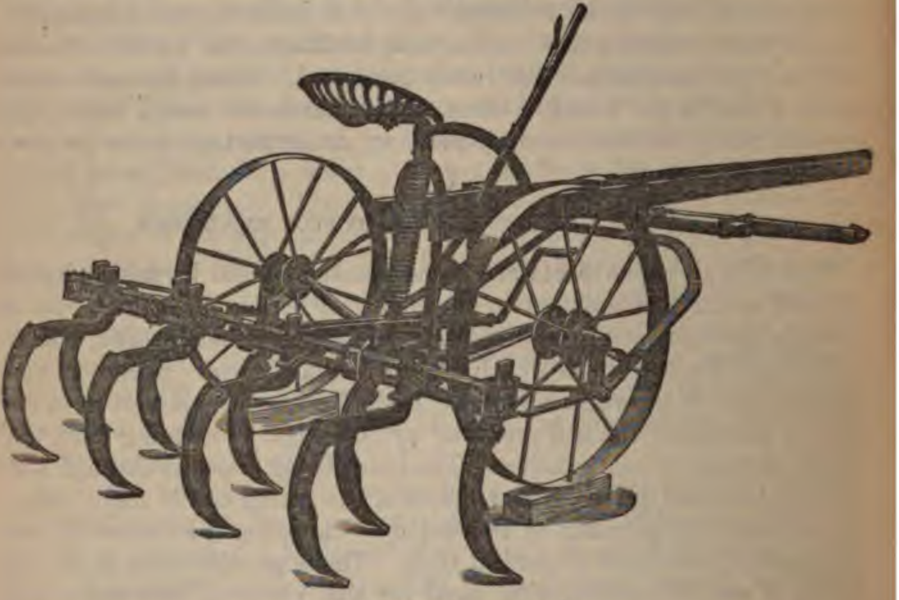


FIG. 5.—Cultivator for sugar beets.

## PLANTING THE SEED.

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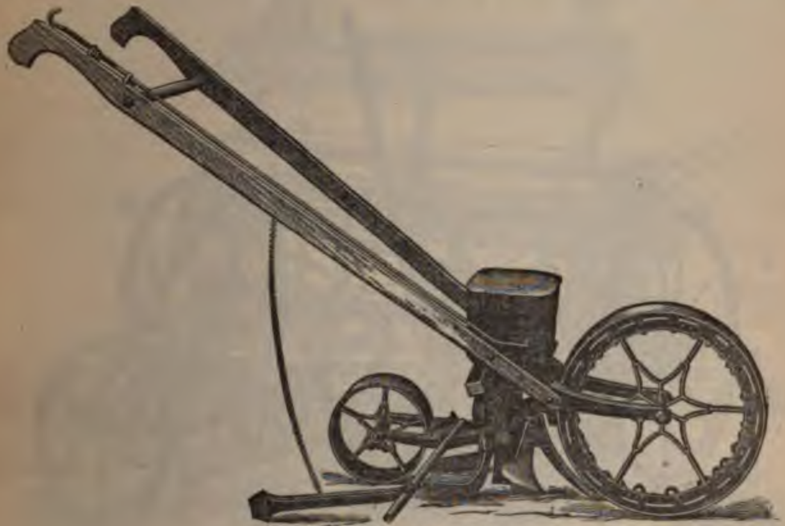

FIG. 6.—Hand seed drill.

The beets should be covered to a depth of one-half inch to 2 inches, according to the state of the soil. If the soil be moist and in excellent condition, the beet seed should not be covered more than half an inch. If, on the other hand, the soil be very dry and early rains are not probable, the seed should be covered to a depth of 2 inches.

In the matter of space between rows there is considerable variation. In some cases the rows are made only 16 inches apart, and in others as wide as 28 inches. In recent years the tendency has been to increase rather than diminish the distance, though much depends on the soil and local conditions. It is argued by many that the greater ease and economy of culture with the wider rows outweigh the increased yields per acre which may be secured in the narrower rows.

When a considerable acreage is planted, it is important to be able to plant two or more rows at a time. The accompanying illustration (fig. 7) shows a seed drill which plants four rows at once.

In planting by hand or by drills an effort should be made to drop the seeds singly and at equal distances apart.

Under irrigation planting can be accomplished at almost any time, as the ground can be irrigated, then cultivated, and the seed planted at once.

Beets should be planted as early in the spring as practicable, but the ground should have sufficient moisture and warmth to cause germination of the seed. Experience has shown that the early-planted beets almost uniformly produce a larger yield with a higher content of sugar than the late-planted. No exact date can be fixed which would be suitable to all localities. In most of the localities in the beet area or the United States it will not be found practicable to plant earlier than the first week in May. In exceptional seasons a part of the sowing can be accomplished in April. On the Pacific coast, especially in central and southern California, the sowing can take place at a much earlier date. In parts of California planting is done in December with favorable results. But if planted too early, some of the beets will go to seed before harvest time. When this happens the percentage of sugar is diminished.

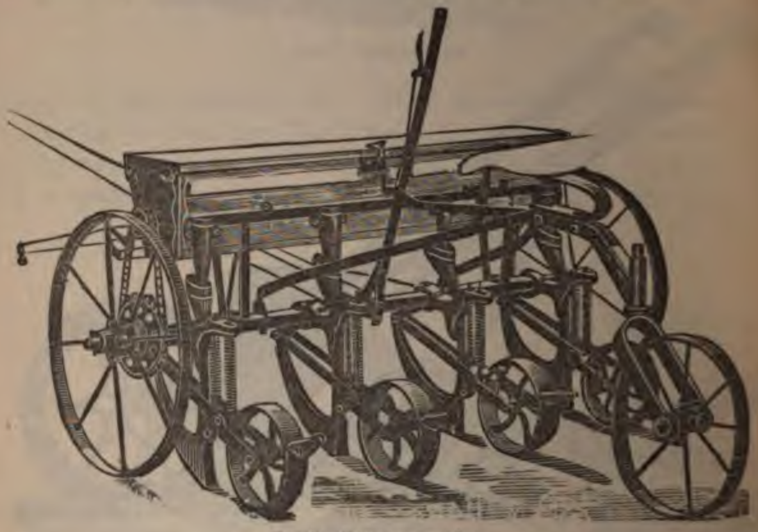

FIG. 7.—Four-row seeder.

Most factories, by way of inducement to early planting, offer free seed for replanting any beet fields that may be injured by frost or other unfavorable conditions. This early planting makes it possible for the factory to begin its campaign earlier in the fall.

## CULTIVATION.

To prevent the formation of a crust, and to keep the weeds and grass from getting a start, it is often necessary to cultivate the beet field with a spike harrow before the plants come up and to continue such cultivation until the beets are large enough for row cultivation to begin. Cultivation must not be postponed or neglected unless wet ground makes it impossible. The purpose of cultivation is twofold: (1) To hold the moisture in the soil; (2) to destroy the weeds and grass, as in the early stages of the beet's growth these can spoil the stand by choking the plants. When the land becomes dry is the most important time for cultivation in order to prevent the escape of moisture from the soil. Cultivation should be continued until the beets have attained such a size that the leaves cover the ground.

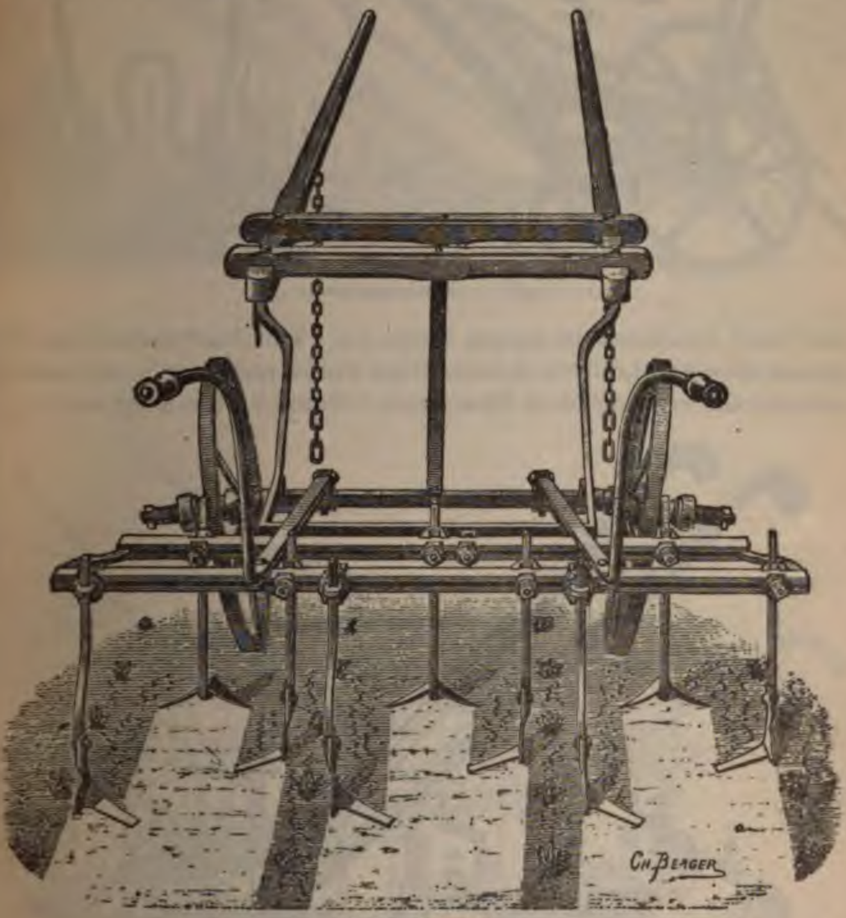

FIG. 8.—Horse hoe.

When large fields are cultivated, the horse hoe, a model of which is shown in figure 8, may be used. For smaller fields a similar apparatus propelled by hand may be employed. Convenient implements of this kind are shown in figures 9 and 10. This implement frees the spaces between the rows of beets from weeds, and guards are used to prevent the growing beets from being covered by the loose soil.

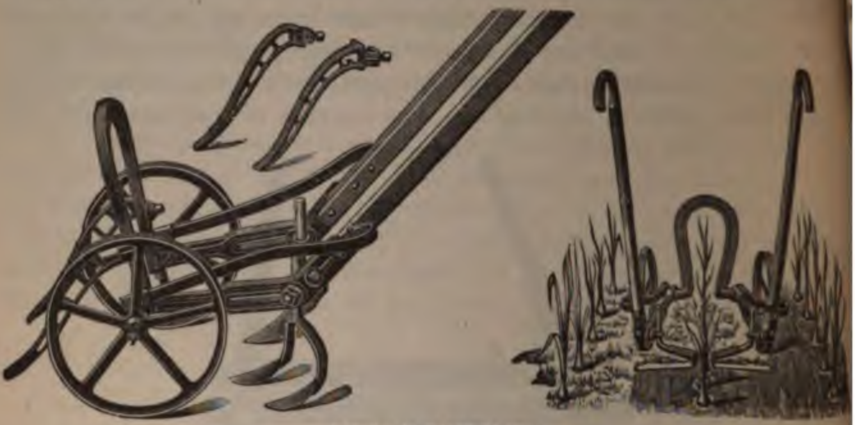

FIG. 9.—Hand-wheel hoes.

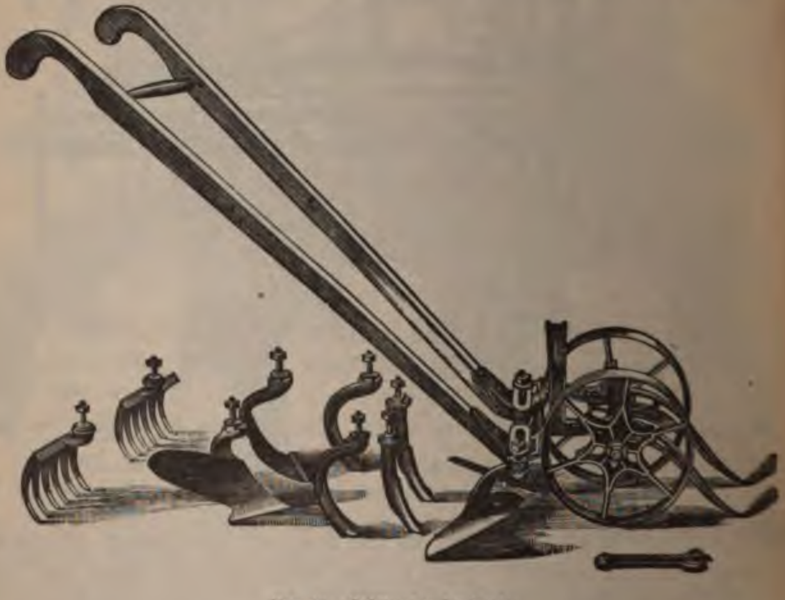

FIG. 10.—Cultivator for beets.

In growing beets with irrigation a cultivator which will prepare the furrow for conducting the water over the field is important. Such a device is shown in figure 11. In this implement the plow shown in the ear of the cultivator teeth forms the required furrow and can be et at any required depth.

In the cultivation of large areas an implement adapted to four ows of beets is desirable. Such an implement, however, can not be dvantageously used, except in those cases where the beets have been own with an implement planting four rows at a time. The cultivator hown in figure 12 is suitable for use on fields which have been planted with the seeder shown in figure 7. Different kinds of devices for cultivation can be easily attached so that the implement can be used as a low, a cultivator, or a harrow.

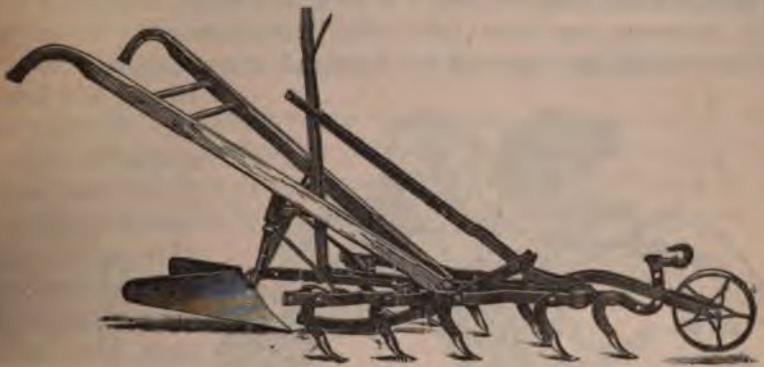

FIG. 11.—Beet cultivator for irrigated lands.

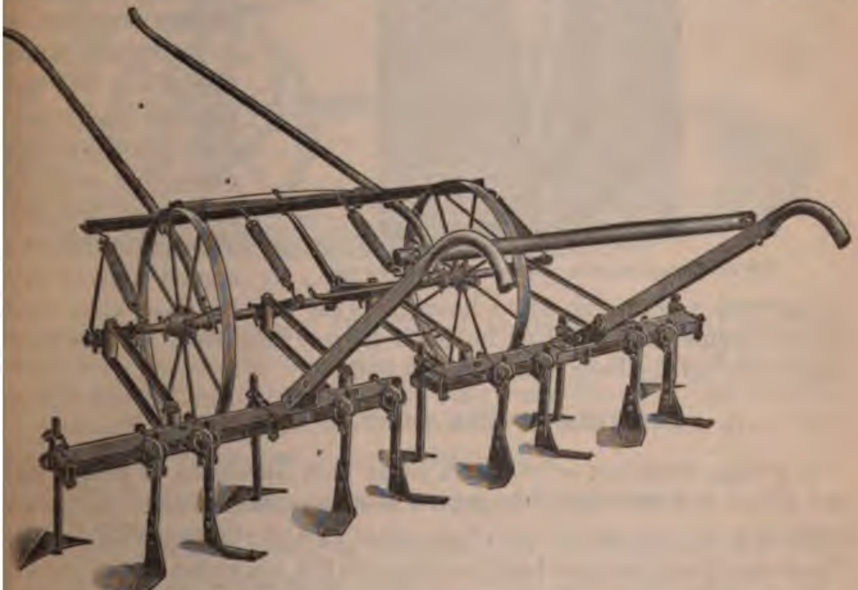

FIG. 12.—Four-row beet cultivator.

## BUNCHING AND THINNING.

When the beets show three or four leaves, they should be bunched and thinned. The bunching is best accomplished with a short-handled hoe. One stroke of this implement takes out all the beets in the row except small bunches from 8 to 10 inches apart, depending on the width between the rows and other circumstances. From these bunches should be removed by hand all the plants but one, the largest and healthiest. Great care should be exercised in this work, and by careful selection all of the inferior plants will be removed. On the proper thinning, the tonnage largely depends. This does not mean that less space should be left between the plants. If the rows be 18 to 24 inches apart, the space between plants can vary from 8 to 10 inches, depending on the nature of the soil. When thinning, it is a good plan to give the ground a thorough hand hoeing. This can be done at a little extra expense and will pay for itself in the long run. If the thinning is put off too long, the crop will suffer.

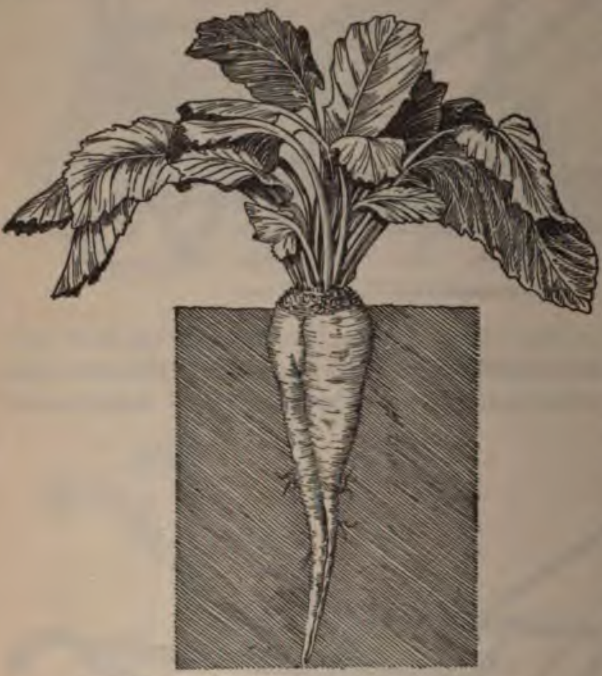

FIG. 13.—Correct position of a mature beet in the soil.

## POSITION OF THE BEET IN THE SOIL.

It is important not only that a sugar beet should be of proper size and shape, but also that it be grown in such a manner as to secure the protection of the soil for all of its parts except the top with foliage. The proper position for a beet to occupy in the soil at the end of growth is shown in figure 13. This position can only be secured for the beet by growing it in a soil sufficiently pervious to permit of penetration by the taproot to a great depth. It is for this reason that subsoiling in the preparation of a field for the growth of sugar beets is of such great importance. If the beet, in its growth, should meet a practically pervious subsoil at the depth of 8 or 10 inches, the taproot will be flected from its natural course, lateral roots will be developed, the et will become disfigured and distorted in shape, and the upper porn of it will be pushed out of the ground. Experience has shown at the content of sugar in that portion of a beet which is pushed ove the soil is very greatly diminished.

### HARVESTING AND DELIVERY OF BEETS.

The time for harvesting varies in different localities. In southern lifornia the beets planted in December are ready for harvesting in latter part of June or the first of July. In general it may be said t beets planted the first week in May will be ready for harvesting

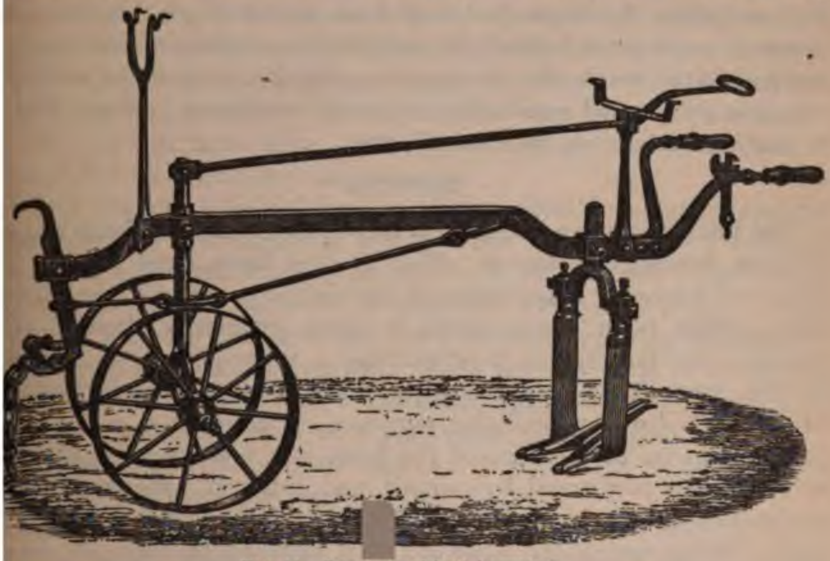

FIG. 14.—One type of beet harvester.

out the 1st of October. Harvesting should be postponed to as late late as possible, provided the beets are in no danger of a second owth and are not exposed to a freezing temperature. The leaves of e ripened beet change from a rich to a yellowish green, droop and close to the earth, and many of them die.

### REMOVING BEETS FROM THE GROUND.

The harvesting is easily accomplished by first loosening the beets the soil and then removing them by hand. For loosening the beets ommon turning plow is often used. The edge of the share cuts off e tap roots at the proper depth and the beets are lifted and thrown er by the moldboard. Better adapted to this work, however, are ws which have been specially constructed for beet harvesting. In ny localities beets are harvested with an implement such as that shown in figure 14. It can be used very successfully where rows are perfectly straight and the beets of uniform size. The lifting part of the apparatus runs deep enough in the soil to catch the beet below its middle part. As the "digger" is drawn forward, the beets are caught between its two prongs, which are nearer together in the rear and slope upward; as a result the beets are lifted and the tap roots broken. After the harvester has passed, the beets are lifted out of the ground by means of the leaves.

Several more or less complicated devices have been invented which are designed not only to lift the beets but to cut off the tops and shake off the adhering dirt. Some ambitious inventors have attempted the construction of a harvester which will not only dig, top, and clean the beets, but load them into a wagon. Such a harvester is much to be desired; but while some of these inventions have worked fairly well under favorable conditions, it must be said that none has yet proved satisfactory under all conditions. Hence the use of such harvesters has been very limited.

## TOPPING.

The next operation consists in removing from each beet the top or neck bearing the leaves. This is done by a large knife. The object of removing this portion of the beet is to prevent the mineral salts, which have accumulated in large quantities therein, from entering the factory, as they exercise a very deleterious influence on the crystallization of the sugar. The tops and leaves are well fitted for feed or for fertilizing purposes. (See p. 39.)

The removal of the tops of the beets is a tedious process, which in Europe is performed by women and children. In this country sometimes the whole family goes to the beet field and performs the work. More commonly, however, it is done by laborers of various nationalities, who are brought in by the factory and with whom the farmer contracts to do this work as well as the hand work of growing the crop.

The topping of the beets can be a source of great waste for the farmer, as too much may be taken off and the tonnage decreased. Constant supervision is necessary in this work. Several attempts have been made to construct a mechanical device by which the beets can be topped, thus saving a large expense, and perhaps a successful device of this kind may some day be invented. So far as is known at the present time, however, this process has not been successfully accomplished by machinery, and the topping must still be done by hand.

When the beets are topped they are thrown into piles, and the leaves are thrown over them as a protection from the sun or frost until they can be delivered to the factory.

## DELIVERING BEETS TO THE FACTORY.

After they are harvested and thrown in piles in the field the beets are usually loaded into wagons and hauled directly to the factory or to a railway station for shipment to the factory. Ordinary farm wagons are often used for this purpose; but wagons specially designed for this work are more satisfactory, and hence are widely used. The bottom and sides of the wagon bed are made of slats with one-half to 1 inch spaces between. As the beets are hauled the shaking and rubbing of the beets tends to free them of adhering soil, which falls out through the cracks. The ends of the wagon bed are stationary and the sides are hinged so as to drop down. These wagons will hold from 3 to 6 tons. A net of rope having from 2 to 3 inch mesh is spread in the wagon first, and on this the beets are thrown. On arrival at the factory the side next the bin is lowered and the projecting net on the other side is fastened to a tackle and raised by power. In this way the load is dumped quickly and with little labor. Sometimes nets are used as a means of lifting beets from ordinary farm wagons.

Where the beets are shipped by rail a special dumping apparatus is installed at the shipping point. The usual form of railroad dump is a high platform approached by a long incline. The loaded wagon is drawn up, the team is unhitched, the wagon locked on the platform, the side dropped, and the platform tipped by machinery. In this way the load is dumped. With another style of dump the wagon is not driven up on a platform, but is left on the ground, the wagon bed being lifted to a height and then dumped.

In cases where there is no railroad dump, a car is placed on a siding and the beets are shoveled into it.

When delivering to the factory, the farmer need not go home with an empty wagon; he can collect manure to be used in fertilizing his fields or can obtain a load of pulp for feed. Most factories, in their contracts with farmers, stipulate that a certain percentage of the weight of the beets delivered can be taken back in the form of pulp. This is a valuable cattle food and the farmer should not miss the opportunity to use it.

## TARING.

In shoveling the beets into wagons for delivery to the factory, a certain amount of extraneous matter, such as stems, tops, and clods of dirt, are also thrown in; moreover, certain soils cling to the beets more than others, especially after wet weather. Some deduction must be made from the weight of the load delivered to account for this. Again, the topping may be very poor, not enough being removed, so that there is a loss to the factory, which should be considered. A sample is taken when the load is dumped into the bins at the factory, the actual percentage of tare is determined, and this figure is applied to the whole load. From the nature of the case, different loads may have a varying percentage of tare, and this point is a constant source of friction between the growers of beets and the factory. But usually it is stipulated in the contract made by the factory with the farmers that the latter may appoint a man to oversee this step in the process.

### SILOING SUGAR BEETS.

When beets are to be preserved for manufacture during the winter months or for the production of seed, they must be carefully protected from the deteriorating effect of freezing and thawing. The simplest and the easiest method is to place them in piles and cover them with earth, not too deeply, for if they become too warm in the silo they rapidly lose in sugar content. When first siloed, they should be covered with only a slight layer of earth; as the cold of winter becomes more intense this covering can be increased. In some localities only a slight covering of straw is necessary to protect the beets, as, for instance, in California. In other localities, such as in Michigan and Wisconsin, it is probable that the beets have to be covered to the depth of 6 inches, and even more, to protect them from frost.

It is most important not to put too many beets in one pile, certainly not over 5 tons. If, however, the silo is made in the form of a rick, no such limitation is necessary. There must be an opening in the top to allow ventilation. In case of a rick there may be several. The silo should be placed on the highest point of land available to provide for proper drainage in case of heavy rains or melting snow. The beets should be siloed on the same day that they are removed from the ground.

The object of siloing, in case of beets for seed, is to prevent them from freezing, and greater care should be used in making the silos. In the case of factory beets, the purpose of siloing is not entirely to prevent freezing, for in the frozen state the beets do not deteriorate to any extent; but it is to keep them fresh and prevent their withering or drying out. Freezing and thawing, however, must be avoided, as beets that freeze and thaw a number of times lose a greater part of their sugar by inversion and decomposition.

It is becoming customary in this country for the sugar companies to ask the farmers to silo part of their beets when the total crop can not be worked up before winter sets in. To repay the farmer for this extra handling they are given a sum varying from 20 cents to 50 cents a ton extra. A few factories situated in the cooler regions where siloing must be practiced agree to take all of the beets of the farmer before frost comes and silo them, but this is not the general practice. In California very little siloing has to be done, and then only by using the leaves as a covering.

## COST AND PROFITS OF GROWING SUGAR BEETS.

The cost of growing an acre of beets depends on so many varying factors as to render it impossible to give an estimate which is reliable for every locality. The differences in rent of land, cost of labor, methods of culture, etc., require that any estimate which may be given should be revised for almost every series of conditions. The following estimate of the cost per acre, made several years ago when wages were somewhat lower than at present, is based on a yield of 12 tons per acre, except in Utah, where the yield was placed at 15 tons.

An assumed yield per acre is requisite in estimating the cost of harvesting, etc., since a part of the cultivation and the harvesting are often contracted at a certain price per ton of beets. The figures given below are from actual averages or from estimates by experienced men.

*Estimated cost per acre of sugar-beet culture.*

| Items. | California. | Utah. | Nebraska. | Michigan. |
|---|---|---|---|---|
| Clearing the land | ........ | ........ | $1.00 to $1.50 | $2.25 |
| Plowing and harrowing | $5.37 | $3.50 | 2.50 to 3.00 | |
| Seed and seeding | 1.80 | 2.75 | 3.25 to 3.85 | 2.50 |
| Bunching and thinning | 14.40 | 4.00 | 7.00 | 7.00 |
| Hoeing | | 4.00 | 2.00 to 4.00 | 4.00 |
| Cultivating | | 2.00 | 1.50 to 1.60 | 1.50 |
| Other expenses | ........ | [a]1.50 | ........ | ........ |
| Harvesting and delivering | [b]1.50 | [c]15.00 | 11.00 to 13.20 | 17.20 |
| Total | 23.07 | 32.75 | 28.25 to 34.15 | 34.45 |
| Cost of siloing when necessary | ........ | ........ | 2.50 to 8.00 | ........ |

[a] Cost of irrigation. [b] Exclusive of delivery. [c] Based on a yield of 15 tons per acre.

In the above estimate was included the cost of the best culture, but nothing for rent of land or a reasonable application of fertilizers. It is probable that the actual cost to our farmers for the first few years of the beet industry did not exceed $25 to $35 per acre and in many instances fell below these figures.

It is reasonably certain, accidents of season aside, that a net profit of from $8 to $15 per acre may be expected from the proper culture of the sugar beet in localities near a factory when all the conditions of the best methods of culture are fulfilled.

For comparison with the above estimate there are given in the following table the actual figures submitted by a Colorado farmer, as published in The American Sugar Industry and Beet Sugar Gazette of June 20, 1907, and also those given by a Wisconsin farmer and a Washington farmer in the same journal for April, 1908.

*Reported cost of sugar-beet culture in three actual cases, and the net returns.*

| Items. | Colorado. | Wisconsin. | Washington. |
|---|---|---|---|
| Number of acres planted | 5 | 11 | 11 |
| Plowing, harrowing, leveling | $8.75 | $34.85 | $24.00 |
| Seed | $12.30 | $39.00 | $26.70 |
| Drilling | $2.25 | $6.40 | $4.00 |
| Thinning | $22.75 | $60.00 | $66.00 |
| Hoeing | $10.25 |  | $30.50 |
| Cultivating and ditching | $9.00 | $27.50 | $17.50 |
| Irrigating | $3.50 |  |  |
| Total cost | $71.05 | $167.75 | $168.70 |
| Average cost per acre | $14.21 | $15.25 | $15.34 |
| Cost of harvesting and delivery |  | $218.00 | $133.15 |
| Total average cost per acre | $27.00 | $35.07 | $27.44 |
| Number of tons of beets harvested |  | 135 | 115 |
| Amount received for beets |  | $695.00 | $607.00 |
| Average receipts per acre |  | $63.18 | $55.18 |
| Net returns per acre |  | $28.11 | $27.74 |

In none of these estimates have the rent of the land or interest on capital been considered. It is not wise to underestimate the actual cost of growing the beets, for this will lead the farmer to expect large profits, which often in practice give way to actual deficits.

## VALUATION OF BEETS AT THE FACTORY.

In the purchase of beets for sugar making the factories offer the growers either a "flat rate" or a "sliding scale." In case the former system is adopted, the factory offers a uniform price of $4.50 or $5 per ton for all beets which reach or exceed a certain minimum standard of quality, as, for instance, a sugar content of 12 or 14 per cent with a purity of 80. In case beets which fall below this standard are offered, the factory may make a reduction in the price or refuse the beets, but no extra price is paid for beets which exceed the standard requirements. If the "sliding scale" is adopted, the factory offers a minimum price of say $4 or $4.25 for beets which reach a minimum standard of quality, as, for instance, 12 per cent of sugar with a purity of 80, and makes an extra allowance per ton of 25 to 35 cents for each per cent of sugar in excess of the established minimum. Under this system beets of extra fine quality may bring $5.50 per ton or even more. Some factories buy all their beets at a flat rate, others buy only according to a sliding scale, while many offer the farmers their choice between the two systems.

In determining the quality of the beets a sample is taken from each load delivered. The percentage of sugar is determined either directly from the beet or from the expressed juice. If from the juice (which is the usual method), the percentage of sugar in the beet is calculated from that in the juice.

According to a United States Census report on the manufacture of beet sugar in 1905, the average prices paid for beets were as follows:

*Prices per ton paid for beets in 1900 and 1905 compared.*

| State. | 1905. | 1900. |
|---|---|---|
| | *Dollars.* | *Dollars.* |
| Colorado | 5.28 | ........ |
| Michigan | 5.52 | 4.38 |
| California | 4.72 | 4.47 |
| Wisconsin | 5.36 | ........ |
| All other States | 5.19 | 4.26 |
| Average for the United States | 5.22 | 4.39 |

A comparison of these figures shows that there was a large increase in the price of beets during this five-year period.

## BEET-SEED PROBLEMS.

### PRODUCTION OF SEED.

The production of seed is one of the most important operations connected with the sugar-beet industry. On the care and skill which are displayed in this process depend the improvement and maintenance of the sugar-producing qualities of the beet. It is, however, an industry in itself and only the result is of practical interest to the average farmer. There are many different methods employed for producing seed which will grow the richest sugar beets, but there will be given here only a general outline of the principles which underlie the process. The beets which are to be preserved for seed are called "mothers" and are selected at the time of harvesting from specially grown beets or from fields of beets which have shown particularly good qualities on analysis. The size of the roots selected for mothers is about the average for the best sugar beets, viz, from 20 to 24 ounces. Smaller beets than these might show a higher content of sugar, but it is not wise to produce a race of small beets. The weight of the mothers having been decided upon, the beets are next selected for their shape and external appearance. Those regular in shape and smooth in external form are to be preferred.

The beets to be preserved for mothers are harvested with the greatest care to avoid injury. The top is not cut away, but the leaves are removed by cutting off the stems without injuring the top of the beet.

They should be siloed in such a way as to protect the beets entirely from frost and yet prevent their growth in the silo until the spring. The beets are removed from the silo at an early date in the spring and are immediately subjected to analysis. The final selection depends upon actually determining the density of the juice and its content of sugar. For this purpose a cylindrical piece of the beet is removed by an appropriate instrument cutting diagonally through the center of the root. This piece may weigh one-half ounce or even more, and its removal does not injure the beet for seed-bearing purposes. The juice is expressed from this piece and its specific gravity determined, as well as the percentage of sugar in the juice. From the specific gravity the amount of solid matter in the juice can be calculated. The percentage of sugar is determined by means of the polariscope.

From these data the quality of the beet is ascertained and the question as to its use as a mother for seed is determined. An important figure in this work is the ratio of sugar to total solids in the beet; that is, the sugar divided by the total solids, the quotient being multiplied by 100. This figure is spoken of as the "coefficient of purity."

The procedure for selecting beets where seed is produced on a commercial scale is in brief as follows: A standard is set for sugar content and also for purity. The beets are analyzed separately and are divided into two classes, namely, those in which either the content of sugar or the purity falls below the fixed figure, and, second, those in which these two numbers equal or exceed the fixed figures. It is sometimes customary to divide the latter class into two portions, viz, those roots in which the numbers equal or slightly exceed the standard, and, second, those which show exceptional richness. It is also customary to number each beet, and the number, which is cut into the skin of the beet, will remain legible even after the seed has ripened. Some of the producers of sugar-beet seed preserve the product of seed from each beet by itself, and do not use it to inaugurate the production of seed for commerce until it has received an additional year's trial.

Many seed producers determine the percentage of sugar in the beet by a direct analysis of a pulped sample and base the selection of the mothers on the number so obtained, without regard to the coefficient of purity, as it has been proven in Germany that a beet of a certain sugar content will under most circumstances have a certain purity.

By careful selection of mother beets and scientific culture the sugar beet has been raised to its present high standard of excellence, and is only maintained at this standard by constant supervision, such as has been indicated.

## DOMESTIC PRODUCTION OF BEET SEED.

The commercial production of beet seed of pure pedigree and high grade has not been practiced to any great extent in this country. Beet seed has been grown for a number of years in the State of Washington and also in Utah. The latter State consumes its own crop, while the seed from Washington has been used in all the beet-growing States. In 1904 the Department of Agriculture distributed 13,962 pounds of American-grown sugar-beet seed, the greater part coming from Washington. This seed went to farmers growing beets for factories, and therefore was tested in direct comparison with the factory seed which is practically always imported. It was tested on 153 farms, representing thirteen different States, 564 acres being planted. The results gave an average yield for Washington-grown seed of 10.72 tons per acre, against 9.92 tons harvested from an equal area raised from imported seed.

To grow sugar-beet seed commercially certain conditions must exist which are not always applicable to experimental work. It is necessary not only that seed of high quality be grown, but also that it be grown economically and that there be reasonable certainty of a crop. Climatic conditions, such as the probability of severe rainfall at the time of harvesting, play an important part in selecting a location for a beet-seed farm. The prevalence of insects and other pests must also be considered.

## COMPARATIVE VALUE OF DOMESTIC AND FOREIGN SEED.

Numerous comparisons of home-grown and imported beet seed have been made. The plants from the native-grown seed seem to have a higher vitality and to be better suited to the climatic conditions of the locality than those grown from imported seeds. They show during the growing season a more abundant foliage and a better development of roots. This higher vitality and quality of the beets grown from domestic seed illustrate in a forcible degree the advisability of the production of our beet seed at home. Even granting that seeds produced in foreign countries have the same high qualities, it must be admitted that their vitality is in danger of being very much diminished during shipment to this country. The moist air in the holds of ships in which they are transported often produces moldiness and incipient germination, which tend to diminish their value greatly. In 1904 American-grown seed yielded 10.72 tons of beets per acre with a sugar content of 15.41 per cent, while imported seed averaged 9.92 tons with 15.26 per cent of sugar, the excess of sugar from the use of American-grown seed being from 300 to 350 pounds per acre. In 1905 American-grown seed yielded 14.32 tons of beets per acre with 14.9 per cent of sugar, while imported seed averaged 12.14 tons with 15.1 per cent of sugar, an excess of more than 600 pounds of sugar per acre of beets. In 1905 the averages were taken from 278 acres. These data should be carefully studied by all those who are interested in the production of beet sugar in this country. At present there is one grower of beet seed on a large commercial scale, and it is certain that it will not be long before there will be a demand for the establishment in this country of more plantations devoted exclusively to the production of beet seed on the most approved scientific principles.

The quantity of seed required to plant an acre is about 15 pounds. The approximate number of acres planted to beets in this country during the season of 1907 was 400,000, requiring 6,000,000 pounds of seed. More than 6,500,000 pounds of seed were required for the crop of 1908. It is evident that there is already an opportunity for the active operation of large plantations devoted exclusively to the production of beet seed for domestic use.

Another point to be considered is that by the importation of foreign seeds there is danger of introducing those diseases of beets which have occasioned such ravages in Europe.

### SINGLE-GERM BEET SEED.

The average beet-seed ball contains from 1 to 7 germs or seeds, each capable under certain conditions of producing a plant. In practice some seed balls will produce as high as seven plants, while others will only produce one. The Bureau of Plant Industry of the Department of Agriculture has undertaken the development of a strain of sugar beets bearing single-germ seed balls, and the results of that work up to 1905 have been published in a bulletin of that Bureau (No. 73). By careful selection, plants bearing 50 per cent of single-germ seeds have been produced. It is confidently expected that in time a plant bearing only single-germ seeds will be produced. The economy in the use of such seed is evident, as, when planted in a row, the thinning can be done by means of a hoe, thus doing away with hand thinning. This work was undertaken in 1902, and up to the present time is still in an experimental stage, none of this seed being available for distribution.

### DISEASES AND INSECTS AFFECTING THE SUGAR BEET.

There are three diseases of the beet which prove especially destructive: One is the "leaf spot" due to a fungus (*Cercospora beticola*), in which the leaves are covered with brown spots and die, forcing the beet to throw out new leaves at the expense of the sugar content and growth of the root. This has been successfully combated on a small scale by spraying with Bordeaux mixture, but whether this can be done economically on a commercial scale is still under investigation. The second disease, "root rot," likewise due to a fungus (Rhizoctonia), in which the roots finally rot off, seems to be increasing. If attended to in time, it can be checked by the use of air-slaked lime. The lime is sprinkled broadcast over the infected area and thoroughly hoed into the soil. The third disease, known as "curly top," causes the leaves to curl up; the beet does not develop but finally dies. No satisfactory means of combating this disease has ar been devised, but a report on the subject has been issued by Bureau of Plant Industry [a] of the Department of Agriculture.

number of other diseases, including "crown rot" and "damping " have been studied, but they are confined to small particular areas d have not wrought the damage that follows the three especially ntioned.

Many species of insects use beets as food. Not more than about species, however, are classed as noticeably destructive to the crop. ny of these have received extended notice in publications of the reau of Entomology [b] of the Department of Agriculture. From se reports the farmer can learn what has been done along this line obtain suggestions as to the means of fighting the pests.

he beet growers should send specimens of insects injurious to ir crops direct to the Bureau of Entomology for specific identifiion and advice as to remedies.

## THE MANUFACTURE OF SUGAR.

### THE FACTORY PROCESS.

he process of making sugar from the sugar beet is only of secary interest to the farmer, and will be treated as briefly as possible, ing merely an intelligent general idea of the methods followed. beets are stored in bins which narrow down to a flume ered by small boards. By removing the boards, one at a time, beets are fed into the flume, where a swift running stream of ter carries them to a wheel or screw that lifts them to a washing k. This is provided with an apparatus for keeping the beets in tion and transferring them toward the end from which the fresh ter enters. In this process the whole of the adhering soil, together th any sand and pebbles, is completely removed. By a suitable vator the beets are next taken to a point above the diffusion baty, where they pass into automatic scales, which dump them when certain weight has been received. From this they are dropped o a slicing apparatus, by which they are cut into thin pieces, called ossettes," of greater or less length, and of such a shape that when ced in the cells of the battery they will not lie so closely together to prevent the circulation of the diffusion liquors. When the cell ull of the sliced beets it is closed and the hot juices from the cell t filled are admitted and allowed to remain in contact with the tings for a few minutes. From 10 to 12 cells are thus kept in use. ile one is filling another is emptying. The fresh hot water is

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U. S. Dept. Agr., Bureau of Plant Industry, Bul. 122.

A Brief Account of the Principal Insect Enemies of the Sugar Beet, Bul. 43, Bur. nt., U. S. Dept. of Agr. Reference is also made to insects of this class in Buls. 29, 33, 54, and 66 of the same series.

always admitted to the cell next to be emptied and passes in suc
sion through all the cells under pressure, until it reaches the one i
filled. From this cell a quantity of juice is drawn off each time a
sent to the carbonatation tanks for purification. With the drawi
off of a certain quantity of the juice, one cell of exhausted beet
the last one in the circuit, is dumped. Figure 15 illustrates in a g
way the arrangement of a diffusion battery, but the circular

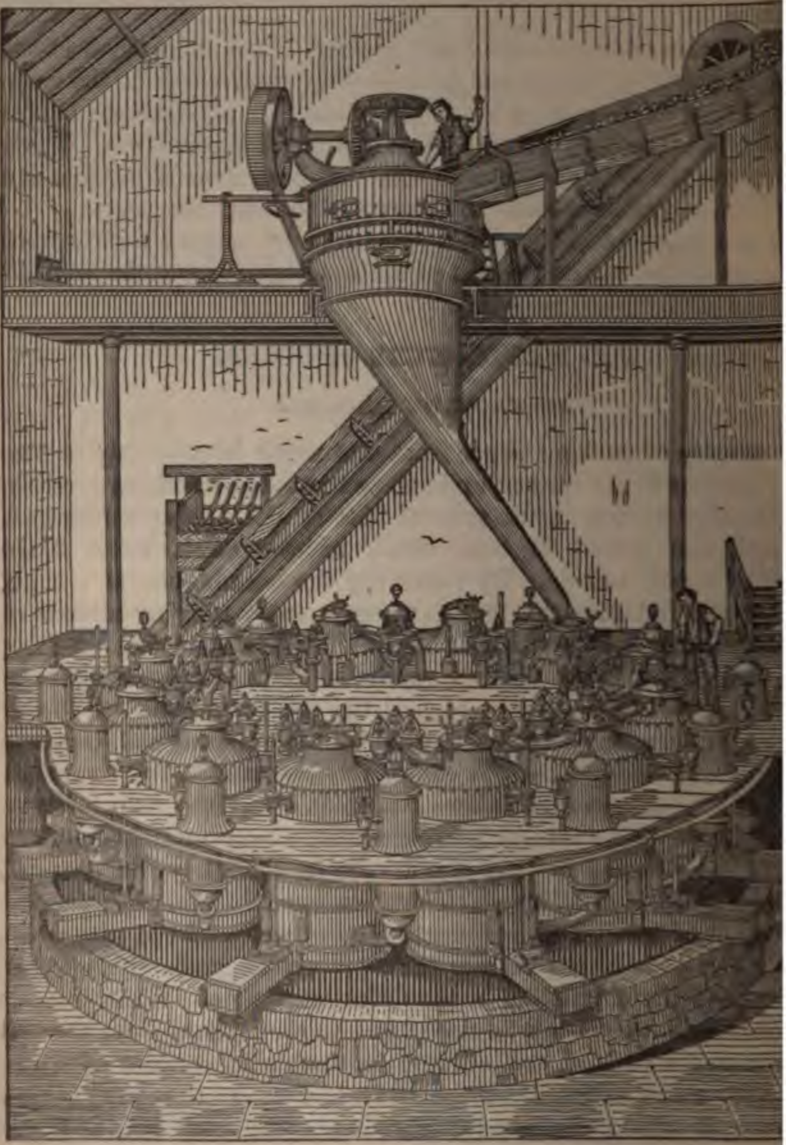

FIG. 15.—Diffusion battery.

there shown is no longer in use, the cells now being arranged in a straight line.

The extracted cuttings are carried by conveyers to a press, where a portion of the water is removed, and they are then "scrolled" out to a silo in suitable condition for use as cattle food. The diffusion juice obtained as above described is conveyed to carbonatation tanks, where it is treated with from 2 to 3 per cent of its weight of lime in the form of a thick milk. The whole is heated and carbonic acid gas (obtained from the limekiln) is pumped into the mixture until a certain alkalinity of the juice is obtained. By this process the impurities in the diffusion juice are to a great extent thrown out and some of the extra lime precipitated also.

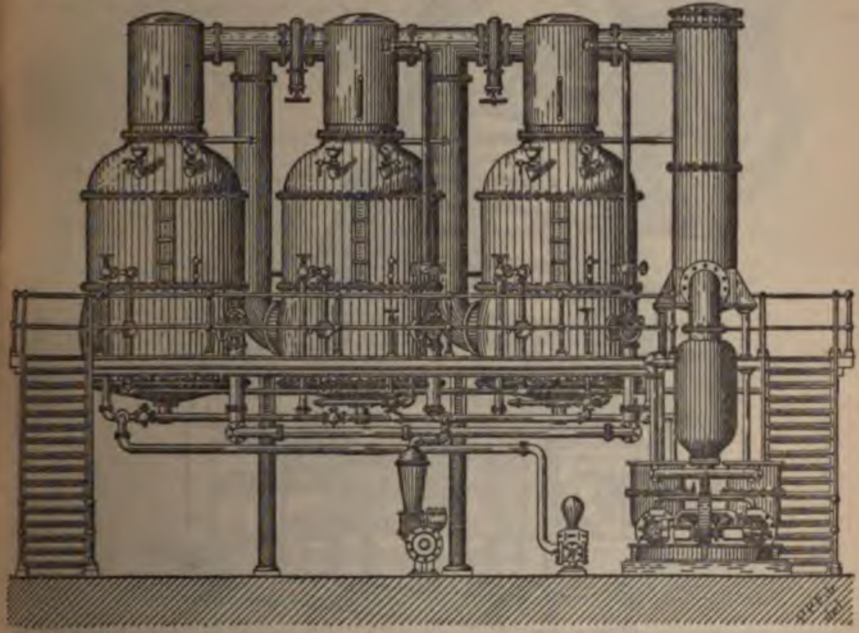

FIG. 16.—Multiple-effect evaporating apparatus.

The slightly alkaline juice is next passed through filter presses, by which the precipitated lime and other solid matters are removed. The juice from these filters then passes to a second set of carbonatation tanks, in which they undergo a treatment similar to that just mentioned, but the quantity of lime added is small as compared with that of the first carbonatation. The refiltered juices from the second carbonatation, usually termed the "saturation," are then sent to tanks, through which the fumes of burning sulphur or sulphur dioxid are passed. This treatment removes more lime and impurities besides lightening the color of the juice. From these tanks the juice goes to another set of filters, generally composed of bags, and from there to storage tanks for the multiple-effect evaporators.

The multiple-effect evaporating apparatus (fig. 16) consists o series of pans connected in such a manner as to secure a progressi higher vacuum. The thin juices enter the first pan, where th may be evaporated, either under slight pressure or in a vacuum. T steam with which this evaporation is effected is usually the w coming from the engines and pumps of the factory.

The vapors generated in the first pan enter the heating pipes of second one, and are thus utilized in evaporating the somewhat con trated sirup which is drawn off from the first pan into the second where the vacuum is higher, being represented by a column of mer of from 12 to 15 inches in height. The vapors which are produce the second pan are in like manner conveyed to the heating pipes third apparatus, where the still more concentrated sirups from second pan are conducted and evaporated at the highest vac obtainable in such apparatus, usually from 26 to 28 inches of merc Usually a fourth pan is employed, but the arrangement is illustrated by the above example. It is easy to see by the arra ment above noted that the evaporation of the thin diffusion juic a heavy sirup is accomplished with the greatest economy, direct st being admitted only into the first pan, and the rest of the opera being accomplished by the steam generated in the evaporation of liquors. The thickened juice from the last effect of the mul

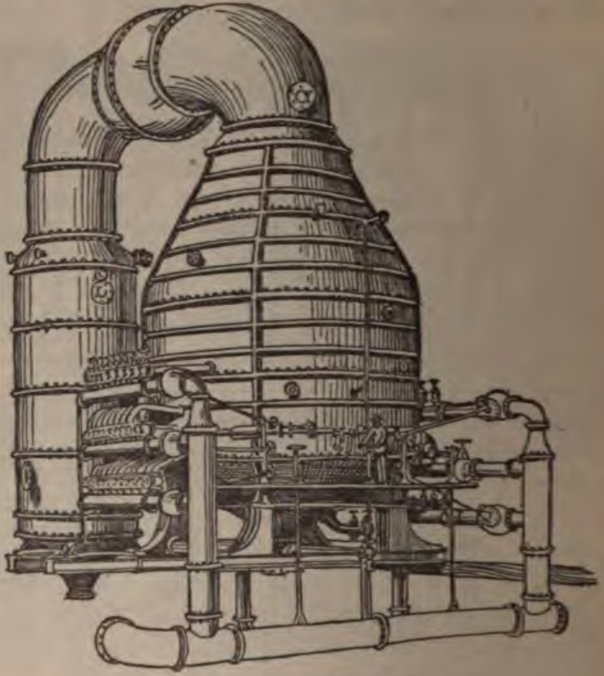

FIG. 17.—Vacuum strike pan.

evaporator is sent to tanks where it is again treated with lime, phosphoric acid, and soda to remove impurities, and also with sulphur dioxid to lighten the color. From here it passes to bag filters and then into storage tanks. This juice is converted into sugar in the following manner:

A portion of the sirup is placed in an evaporating apparatus called the strike pan. This apparatus is very large, usually a cylindrical vessel with a conical bottom, and is provided with a series of coils, one above the other, to which the steam can be admitted at will. The admission of steam is always so regulated that it is not allowed to enter any of the coils above the surface of the liquid in the pan. The portion of sirup first introduced is evaporated until it reaches a point of consistency which will permit of the formation of crystals, i. e., supersaturation. In this condition, if a portion of fresh sirup be introduced the whole mass in the pan becomes charged with exceedingly fine crystals of sugar.

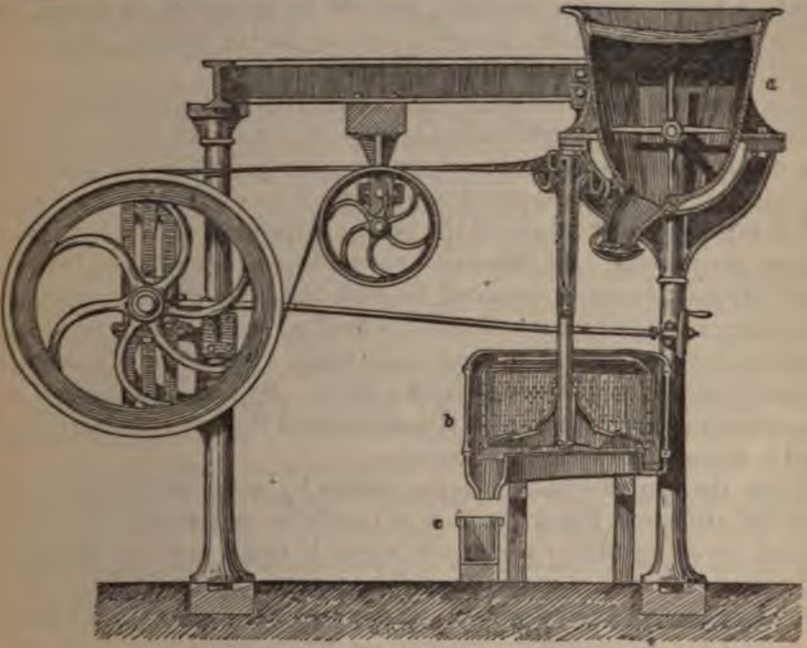

FIG. 18.—Centrifugal apparatus: *a* holder for massecuite; *b* centrifugal basket with fine wire lining *c* molasses trough.

By careful manipulation and the introduction of new quantities of sirup from time to time these crystals are made to grow. As the pan becomes full successive coils of the steam pipes are brought into use, so that the boiling surface of the pan is gradually increased in proportion to the volume of its contents. In the course of a few hours the skilled sugar boiler will find that the pan is full and that the crystals have grown to the proper size. The charge in the vacuum pan at this stage is extremely heavy, consisting of a dense mass of sugar crystals mixed with a quantity of molasses which varies in amount with the purity of the juices from which the sugar is made. This product is termed massecuite. The illustration (fig. 17) shows the vacuum pan. In boiling sugar in a vacuum pan, if the highest possible yield is desired and no objection arises to the formation of soft crystals, a very high vacuum, equivalent to 29 inches of mercury at the sea level, is employed. At this vacuum the sirups boil at a temperature of from 112° to 120° F. If harder crystals, giving a somewhat less yield are desired, as in the case of making granulated sugars, a lower vacuum, namely, from 24 to 26 inches, is employed.

The massecuite is then dropped directly to the mixer, where it is stored for charging the centrifugals below it.

The construction of the centrifugal apparatus and mixer is shown in figure 18. The centrifugal basket is suspended and run by the spindle. The whole basket is incased in an armor-plate jacket and is lined with fine wire gauze. The charge of massecuite is let down into the basket, which is revolved by means of the belt at a speed of about 1,200 revolutions per minute. At this speed the molasses is separated from the sugar crystals, being thrown out through the holes of the screen onto the outer jacket, where it collects and finally runs through the trough, provided for the purpose, to the storage tank. The color of the charge is now changed from brown to light yellow. By a sprinkling can or a small spray of water the rest of the molasses in the fast running centrifugal is washed off of the crystals.

From the centrifugals the sugar passes by belts and conveyers to bins for storage. From these it is carefully and slowly fed into a heated revolving drum where the sugar is dried and the masses of individual crystals are broken up. This is termed granulation. From this point the sugar passes to weighing machines where it is barreled or sacked for commerce.

The resulting molasses is still rich in sugar and is brought back to the vacuum pan where it is boiled to a massecuite which is placed in large double-jacketed tanks having a revolving worm. The double jacket is filled with heated water and the massecuite is allowed to stay in the tank for a number of days, being mixed by the revolving arm. The temperature is allowed to fall slowly and by this means more crystals of sugar are formed. When no more of the sugar will crystallize, the tank or "crystallizer" is emptied into another set of centrifugals and the sugar is spun off. This crop is generally very dark in color and washing does not lighten it to a white sugar. It is known cond sugar and is melted in water and boiled up with the juice the evaporator in the vacuum pan to make white sugar. In its state it is not the same as the yellow sugar of commerce, being rally salty and disagreeable in taste. The resultant molasses is etimes boiled for a third crop of sugar, but generally it is sent to age or is used in the osmose or Steffens process for removing more r from the molasses.

the osmose process a stream of heated, diluted molasses is run in a able press in the opposite direction to a stream of hot water, a t of parchment paper separating the two streams. By this means eater portion of the salts passes through the membrane and enters vater which flows away. The sirup is made richer, and by boiling e evaporator and in the pan a massecuite is formed that is stored ystallizers, and finally the sugar is spun off. The remaining mos is sometimes reosmosed, but generally it is sold to be mixed pulp or grain for cattle food or is used for alcohol making.

the Steffens process the molasses is diluted and cooled to a low perature, which is kept constant while finely powdered fresh lime is ed slowly. In this way a saccharate of lime is formed which is luble in the liquid, and by passing the whole material through r presses it is separated. The cake from the presses is diluted water and takes the place of the milk of lime used in the carbona. When this process is employed there is no residue molasses; the waste is the strongly alkaline water containing the salts of the asses which have been separated from the saccharate of lime. This er is rich in potash salts and could be used as a fertilizer.

he beet-sugar factories of this country sell only the white granud sugar; none of them produce raw sugar and turn it over to the eries to be passed over bone black and made into white sugar, as e custom in Europe.

## COST OF MANUFACTURE.

he cost of manufacture depends on as many factors as that of beet ving. Chief among these are transportation, fuel, weather, and r. Perhaps the most important of these factors is the price of . In some localities coal can be had for $1.25 per ton; in others cost may reach as high as $10 per ton.

he manufacture of beet sugar is conducted without governmental ervision in this country, and any exact account of its cost is inacible. To show what it may be, when a wide experience and the management are brought to bear upon the work, the mean cost anufacture in 113 German factories is given.

| | | |
|---|---|---|
| Mean capital invested in each factory | | $193 |
| Total receipts for sugar, molasses, and pulp per ton of beets | | |
| Mean cost of beets per ton of 2,204.62 pounds | $4.90 | |
| Salaries per ton of beets | .26 | |
| Labor per ton of beets | .73 | |
| Interest on investment per ton of beets | .36 | |
| Coal per ton of beets | .63 | |
| Miscellaneous expenses per ton of beets | .96 | |
| Total expense of manufacture per ton | | |
| Profit per ton of beets | | |

The mean net profit for each factory was $34,240. The price
for beets, however, is in most cases fictitious, the beet growers ow
the factory and preferring to share in the general profits rather tha
charge a high price for the beets. First-class beets rarely sell for
than $5 per ton. The Western Beet Sugar Company, of Watson
Cal., stated that in its first campaign, 1888–89, the cost of manu
ture amounted to $80.80 per ton of sugar. At the present tim
appears that with the best machinery, rich beets, and most econom
processes beet sugar can be made in this country at a cost of less
4 cents per pound, even when the price of rich beets exceeds $5 a

## COST AND CAPACITY OF FACTORIES.

The cost of building a first-class beet-sugar factory is much gre
than is commonly supposed. Roughly speaking, for every to
daily capacity, the plant costs $1,000; that is, a 500-ton plant w
cost $500,000 and a 1,000-ton factory would cost $1,000,000. It
been demonstrated in the United States that a beet-sugar mil
order to work economically, must have a capacity to work 500 ton
beets daily, and that one having a capacity of much more than 1
or 1,500 tons a day is unwieldy. The largest factory in the Un
States can handle 3,000 tons a day. In Germany there are a
small factories of 200 and 300 tons capacity, but the tendency of
has been to increase the size. In the early days of the beet-s
industry in this country, Europe was called on to furnish all mac
ery. Now, very little is imported, and, in fact, some of the for
factories are using American-made machinery.

## COOPERATIVE FACTORIES.

It is seen from the foregoing paragraph that the farmer can hav
reasonable hope of successfully establishing a home beet-sugar fact
It is not just, however, that he should be deprived of any coopera
in the process of manufacture or a reasonable share of the profits
ing therefrom. The methods which have been practiced in Eu
for securing these results may eventually come into use in this co
try. The cooperative sugar factory, in which the farmers growing

beets hold a part or a majority of the stock, realizes the desired end. The growers of beets holding shares in the factory have a greater interest in its prosperity and try to grow better crops and to secure in every way a higher yield. The cooperative factory renders impossible those disagreements between factory and agriculture which do so much to retard the progress of the industry and to embitter the farmers against the factory. To show the extent of the participation of shareholders in factories in the growing of beets in Germany, it may be stated that of the 11,672,816 metric tons of beets delivered to the German factories in 1895–96, 2,689,004 tons were grown by shareholders. As long as the proprietors of the factory and the farmers growing the beets are satisfied with the contracts which they make, there is no urgent necessity for the establishment of cooperative enterprises. When the number of beet-sugar factories in this country, however, begins to reach the hundreds, favorable opportunities for cooperative establishments will be presented.

## USES OF BY-PRODUCTS.

The by-products from beet culture on the farm are the tops and leaves, which are commonly used for feeding cattle. Some farmers, however, turn them under as a fertilizer. When used as a feed, the beet tops can be eaten by the cattle on the field where they have been grown. If they are fed in stalls, the manure should be returned to the field.

The by-products of the factory consist of pulp, lime cake, and molasses. The pulp is a valuable cattle food and the farmer should contract with the sugar company to obtain his share of it. It can be stored in siloes, if well drained, and be fed fresh or in a fermented condition. The value of the pulp for feeding purposes is variously estimated at from one-fifth to one-third the value of the beets. Its sugar content is not sufficient to make it of any value as a source for alcohol manufacture. Lime cake in most factories is washed out with water to the sewer. In others it is wheeled out and dumped in piles and can be used on some lands as a fertilizer, though for this purpose the demand for it is limited. Lately it has been used in cement making. Molasses has a value as a cattle food, but it must not be fed very heavily or scouring of the cattle will result. The best practice is to sprinkle it on the hay, alfalfa, or roughage. Some factories mix the molasses with the pulp and dry the whole, either pressing it into bricks or selling it loose. With the increased installation of the Steffens process of desugarizing molasses, there is not so much molasses resulting from beet-sugar manufacture as was obtained a few years ago. In an economical plant all molasses should go through this process and only that produced at the end of the season be saved. It is a question whether the introduction of denatured alcohol into the arts, as well as for fuel and light, will not tend to reduce the number of Steffens plants and result in the sale of the molasses for distillation. Beet molasses contains about 50 per cent of sugars capable of fermentation. One gallon weighing about 12 pounds contains approximately 6 pounds of sugar, which will produce about 3 pints of 95 per cent alcohol. In other words, for every 2½ gallons of molasses 1 gallon of alcohol can be made.

## STATISTICS OF PRODUCTION AND CONSUMPTION OF SUGAR.

In the data giving the production and consumption of sugar the unit of value commonly employed is the ton. By reason of the fact that the ton in this country expresses a unit of varying magnitude a considerable degree of confusion is often introduced into statistical tables. In the following tables the kind of ton used is specified in each case. The long ton, which is often used in compiling sugar statistics, contains 2,240 pounds. The short ton, namely, 2,000 pounds, is a more convenient unit of expression, and is largely used in the publication of sugar statistical data in this country. The metric ton, which is used on the continent of Europe, is a weight of 1,000 kilograms, equivalent to 2,204.62 pounds.

### BEET-SUGAR PLANTS IN THE UNITED STATES.[a]

The following table gives a complete list of beet-sugar plants in the United States, arranged by States, showing the official names of the manufacturing companies and the locations of the factories. It also shows the daily slicing capacity, expressed in tons of beets, for each factory, the combined daily slicing capacity of the factories in each State, and the aggregate capacity of all the factories in the United States.

*Beet-sugar companies and factories of the United States.*

| Manufacturing companies. | Factory locations. | Number of factories. | Daily slicing capacity. |
|---|---|---|---|
| California: | | | *Tons of beets.* |
| Alameda Sugar Co | Alvarado | | 800 |
| Los Alamitos Sugar Co | Los Alamitos | | 700 |
| Spreckels Sugar Co | Spreckels | | 3,000 |
| Union Sugar Co | Betteravia | | 600 |
| American Beet Sugar Co., main office, 32 Nassau street, New York; Pacific coast office, 604 Mission street, San Francisco. | Chino | | 900 |
| | Oxnard | | 2,000 |
| Pacific Sugar Corporation, Los Angeles, Cal | Visalia | | 600 |
| Pacific Sugar Construction Co | Hamilton City | | 700 |
| Total | | 8 | 9,100 |
| Colorado: | | | |
| American Beet Sugar Co., 1530 Sixteenth street, Denver, Colo. | Rocky Ford | | 1,100 |
| | Lamar | | 600 |
| | Las Animas | | 700 |
| Holly Sugar Co | Holly | | 600 |
| Holly Construction Co | Swink | | 1,200 |
| National Sugar Manufacturing Co | Sugar City | | 500 |

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[a] From Progress of the Beet-Sugar Industry in the United States, 1907. Report 86, U. S. Dept. of Agr.

## *Beet-sugar companies and factories of the United States*—Continued.

| Manufacturing companies. | Factory locations. | Number of factories. | Daily slicing capacity. |
|---|---|---|---|
| ontinued. | | | *Tons of beets.* |
| at Western Sugar Co., general offices, Building, Denver, Colo. | Eaton | | 600 |
| | Greeley | | 600 |
| | Loveland | | 1,200 |
| | New Windsor | | 600 |
| | Longmont | | 1,200 |
| | Fort Collins | | 1,200 |
| | Sterling | | 600 |
| | Brush | | 600 |
| | Fort Morgan | | 600 |
| tern Sugar and Land Co | Grand Junction | | 600 |
| | | 16 | 12,500 |
| aho Sugar Co., main office, Salt Lake City, | Idaho Falls | | 1,200 |
| | Sugar | | 1,200 |
| | Blackfoot | | 600 |
| | Nampa | | 750 |
| l | | 4 | 3,750 |
| pe, Chicago, Ill | Riverdale | 1 | 350 |
| ar Co | Waverly | 1 | 500 |
| tates Sugar and Land Co | Garden City | 1 | 850 |
| Sugar Co., general offices, Saginaw, Mich. | Bay City | | 600 |
| | Caro | | 1,200 |
| | Alma | | 700 |
| | Carrolton | | 850 |
| | Sebewaing | | 600 |
| | Croswell | | 600 |
| y City Sugar Co | Bay City, West Side | | 600 |
| Sugar Co | Holland | | 300 |
| ugar Co., main office, Bay City, Mich | Owosso | | 1,250 |
| | Lansing | | 600 |
| American Sugar Co | Bay City, Station A | | 650 |
| ens Sugar Co | Mt. Clemens | | 600 |
| ee River Sugar Co | Menominee | | 1,200 |
| Sugar Co | St. Louis | | 600 |
| inental Sugar Co., main office, Cleveland, | Blissfield | | 600 |
| higan Sugar Co | Charlevoix | | 600 |
| | | 16 | 11,550 |
| ounty Sugar Co | Chaska | 1 | 600 |
| t Western Sugar Co | Billings | 1 | 1,200 |
| Beet Sugar Co | Grand Island | 1 | 350 |
| et Sugar Refining Co | Lyons | 1 | 600 |
| tal Sugar Co | Fremont | 1 | 400 |
| ated Sugar Co | La Grande | 1 | 400 |
| ated Sugar Co., office, Ogden, Utah | Logan | | 600 |
| | Ogden | | 400 |
| Sugar Co | Lewiston | | 600 |
| ho Sugar Co., main office, Salt Lake City, | Lehi[a] | | 1,200 |
| | Garland | | 1,200 |
| | | 5 | 4,000 |
| ton State Sugar Co., main office, Spokane, | Waverly | 1 | 500 |
| n Sugar Co., main office, Milwaukee, Wis. | Menomonee Falls | | 500 |
| Sugar Co., main office, Milwaukee, Wis. | Chippewa Falls | | 600 |
| nty Sugar Co | Janesville | | 600 |
| tates Sugar Co | Madison | | 600 |
| | | 4 | 2,300 |
| total | | 63 | 48,950 |

[a] Slicing stations at Springville, Spanish Fork, and Provo.

## BEET-SUGAR PRODUCTION IN THE UNITED STATES, 1830-1907.

The following table shows the production of beet sugar in the United States from the beginning of the industry to the close of the season of 1907. The data for 1897 and for 1901–1907 are from reports published by the United States Department of Agriculture on Progress of the Beet-Sugar Industry in the United States. Figures for other years are from Willett & Gray. (See Yearbook, U. S. Department of Agriculture, 1907, pp. 687, 688.)

*Beet sugar produced in the United States, 1830–1907.*[a]

| | | | |
|---|---|---|---|
| 1830 | A few hundred pounds | 1890 | 3,459 tons |
| 1831–1837 | None | 1891 | 5,356 tons |
| 1838–39 | 1,300 pounds | 1892 | 12,018 tons |
| 1839–1862 | None | 1893 | 19,950 tons |
| 1863–1871 | 300 to 500 tons per annum | 1894 | 20,092 tons |
| 1872 | 500 tons | 1895 | 29,220 tons |
| 1873 | 700 tons | 1896 | 37,536 tons |
| 1874–1877 | Under 100 tons per annum | 1897 | 40,398 tons |
| 1878 | 200 tons | 1898 | 32,471 tons |
| 1879 | 1,200 tons | 1899 | 72,944 tons |
| 1880 | 500 tons | 1900 | 76,859 tons |
| 1881–82 | Less than 500 tons | 1901 | 164,827 tons |
| 1883 | 535 tons | 1902 | 194,782 tons |
| 1884 | 953 tons | 1903 | 214,825 tons |
| 1885 | 600 tons | 1904 | 216,173 tons |
| 1886 | 800 tons | 1905 | 279,393 tons |
| 1887 | 255 tons | 1906 | 431,796 tons |
| 1888 | 1,861 tons | 1907 | 413,954 tons |
| 1889 | 2,203 tons | | |

## PRODUCTION OF SUGAR BEETS AND OF BEET SUGAR IN THE UNITED STATES, 1901-1907.

The following statements are taken from Report No. 86, Progress of the Beet-Sugar Industry in the United States in 1907:

The acreage planted to sugar beets in the United States in 1907, together with the percentage abandoned owing to unfavorable weather conditions, mistakes of growers, or other causes, is shown in the following table:

*Acreage planted to beets in 1907.*

| State. | Planted. | Abandoned. | State. | Planted. | Abandoned. |
|---|---|---|---|---|---|
| | *Acres.* | *Per ct.* | | *Acres.* | *Per ct.* |
| California | 52,823 | 10.3 | Wisconsin | 13,800 | 14.2 |
| Colorado | 134,848 | 5.3 | Ten other States | 45,197 | 9.0 |
| Idaho | 29,051 | 10.7 | | | |
| Michigan | 95,302 | 7.3 | The United States | 400,953 | 7.5 |
| Utah | 29,932 | 4.2 | | | |

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[a] In long tons of 2,240 pounds.

nparison with the acreage harvested shows that about 30,000 or 7½ per cent, of the acreage planted was abandoned. Con-
n with the figures for the preceding year shows that the acreage
ed exceeds that for 1906 by 3,338 acres, while the acreage
sted is about 5,000 less, the acreage abandoned in 1906 being
5.2 per cent. The increased loss of acreage was due mainly to
orable spring weather, particularly in Wisconsin, Nebraska,
, and California.

*General factory and farm results.*

BY STATES, FOR 1907.

| tate. | Factories in operation. | Area harvested. | Average yield of beets per acre. | Beets worked. | Sugar manufactured. | | Estimated average extraction of sugar. | Average sugar in beets. | Average purity coefficient of beets. | Average length of campaign. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Pounds. | Tons.[a] | | | | |
| | | *Acres.* | *Tons.*[a] | *Tons.*[a] | | | *P. ct.* | *P.ct.* | | *Days.* |
| a | 8 | 47,387 | 10.23 | 484,816 | 146,045,500 | 73,023 | 15.06 | 17.9 | 85.1 | 73 |
| | 16 | 127,678 | 11.93 | 1,523,303 | 338,573,000 | 169,286 | 11.11 | 15.3 | 81.5 | 127 |
| | 4 | 25,938 | 9.41 | 244,080 | 75,928,200 | 37,964 | 15.55 | 17.8 | 88.3 | 88 |
| 1 | 16 | 88,334 | 7.89 | 696,785 | 169,452,000 | 84,726 | 12.16 | 15.1 | 84.7 | 70 |
| | 5 | 28,663 | 12.32 | 353,159 | 88,973,500 | 44,487 | 12.60 | 16.3 | 86.0 | 116 |
| in | 4 | 11,837 | 10.37 | 122,800 | 30,320,000 | 15,160 | 12.35 | 15.1 | 85.6 | 61 |
| aving but e factory:[b] | | | | | | | | | | |
| ois<br>sas<br>esota<br>tana<br>aska<br>York<br>on<br>hington | 10 | 41,147 | 8.33 | 342,928 | 77,964,230 | 38,982 | 11.37 | 15.1 | 82.3 | 70 |
| als and averages.[c] | 63 | 370,984 | 10.16 | 3,767,871 | 927,256,430 | 463,628 | 12.30 | 15.8 | 83.6 | 89 |

TOTALS AND AVERAGES, BY YEARS, 1901-1906.[d]

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *Acres.* | *Tons.*[a] | *Tons.*[a] | *Pounds.* | *Tons.*[a] | *P. ct.* | *P.ct.* | | *Days.* |
| | 63 | 376,074 | 11.26 | 4,236,112 | 967,224,000 | 483,612 | 11.42 | 14.9 | 82.2 | 105 |
| | 52 | 307,364 | 8.67 | 2,665,913 | 625,841,228 | 312,921 | 11.74 | 15.3 | 83.0 | 77 |
| | 48 | 197,784 | 10.47 | 2,071,539 | 484,226,430 | 242,113 | 11.69 | 15.3 | 83.1 | 78 |
| | 49 | 242,576 | 8.56 | 2,076,494 | 481,209,087 | 240,604 | 11.59 | [e]15.1 | (f) | 75 |
| | 46 | [g]216,400 | 8.76 | 1,895,812 | 436,811,685 | 218,406 | 11.52 | [e]14.6 | [e]83.3 | 94 |
| | 36 | 175,083 | 9.63 | 1,685,689 | 369,211,733 | 184,606 | 10.95 | 14.8 | 82.2 | 88 |
| verages 901-1906 | ....... | 252,547 | 9.66 | 2,438,593 | 560,754,027 | 280,377 | 11.50 | 15.0 | 82.8 | 86 |

of 2,000 pounds each.

ped together to avoid giving publicity to the data of individual factories.

average yield of beets per acre is found by dividing the total beets worked by the total acreage d; the average extraction by dividing total sugar produced by total beets worked; the average of sugar, coefficients of purity, and length of campaigns by adding the figures reported by the factories and dividing by the number of factories reporting.

piled from the annual reports on Progress of the Beet-Sugar Industry in the United States.

e averages are not based on data for all the factories, as some of them failed to report results but it is believed that they fairly represent the average character of the total beet crops.

ata reported.

d on reports from 27 factories and careful estimates for 15 others.

## CONSUMPTION OF SUGAR IN THE UNITED STATES.

The following table shows the quantities of imported sugar (both cane and beet) consumed in this country during the past three years, the quantity of domestic cane, beet, and maple sugars, and the quantities of sugar made in this country from imported molasses. Of the total quantity consumed in 1907, nearly 80 per cent was imported either from foreign countries or the insular possessions of the United States, while less than 13 per cent was domestic beet sugar. The total annual consumption has nearly reached 3 million tons of 2,240 pounds.

*Consumption of sugar in the United States, 1905-1907.*

[According to Willett & Gray, January 9, 1908.]

| Kind and origin. | 1907. | 1906. | 1905. |
|---|---|---|---|
| | *Tons.*[a] | *Tons.*[a] | *Tons.*[a] |
| Cane and beet sugar from foreign countries and insular possessions | 2,337,352 | 2,281,599 | 2,056,092 |
| Cane sugar, Louisiana and Texas | 264,968 | 267,947 | 334,522 |
| Beet sugar, United States | 375,410 | 300,317 | 220,722 |
| Maple sugar | 10,000 | 6,000 | 9,000 |
| Molasses sugar, made in United States from foreign molasses | 6,249 | 8,150 | 11,880 |
| Total domestic sugar | 656,627 | 582,414 | 576,124 |
| Total consumption of all sugars | 2,993,979 | 2,864,013 | 2,632,216 |

[a] Tons of 2,240 pounds.

The total annual consumption of sugar in the United States, the percentage of increase or decrease year after year, and the per capita consumption for the years 1884-1907 are shown in the table which follows. The total consumption has increased nearly 140 per cent, while the per capita consumption has increased over 52 per cent since 1884.

*Consumption of sugar in the United States for twenty-four years, 1884-1907.*

[According to Willett & Gray.]

| Year. | Total amount sugar consumed. | Increase (+) or decrease (−).[a] | Consumption per capita. | Year. | Total amount sugar consumed. | Increase (+) or decrease (−).[a] | Consumption per capita. |
|---|---|---|---|---|---|---|---|
| | *Tons.*[b] | *Per cent.* | *Pounds.* | | *Tons.*[b] | *Per cent.* | *Pounds.* |
| 1884 | 1,252,366 | + 7.01 | 51.00 | 1896 | 1,940,086 | −0.49 | 60.90 |
| 1885 | 1,254,116 | + 0.14 | 49.95 | 1897 | 2,070,978 | +6.75 | 63.50 |
| 1886 | 1,355,809 | + 8.11 | 52.55 | 1898 | 2,002,902 | −3.29 | 60.30 |
| 1887 | 1,392,909 | + 2.74 | 53.11 | 1899 | 2,078,068 | +3.75 | 61.00 |
| 1888 | 1,457,264 | + 4.62 | 54.23 | 1900 | 2,219,847 | +6.83 | 66.60 |
| 1889 | 1,439,701 | − 1.21 | 52.64 | 1901 | 2,372,316 | +6.87 | 69.70 |
| 1890 | 1,522,731 | + 5.77 | 54.56 | 1902 | 2,566,108 | +8.17 | 72.80 |
| 1891 | 1,872,400 | +22.96 | 67.46 | 1903 | 2,549,642 | −0.64 | 70.90 |
| 1892 | 1,853,370 | − 1.02 | 63.76 | 1904 | 2,767,162 | +8.53 | 75.30 |
| 1893 | 1,905,862 | + 2.83 | 63.83 | 1905 | 2,632,216 | −4.88 | 70.50 |
| 1894 | 2,012,714 | + 5.55 | 66.64 | 1906 | 2,864,013 | +8.81 | 76.10 |
| 1895 | 1,949,744 | − 3.13 | 64.23 | 1907 | 2,993,979 | +4.54 | 77.54 |

[a] As compared with the preceding year.

[b] Tons of 2,240 pounds.

Although in recent years the beet-sugar industry has made great strides in the United States, and there has been some growth of the cane-sugar industry, the increase in production has not by any means kept pace with the increase in consumption. In fact, much more foreign sugar is consumed now than was the case ten years ago. In 1897 our total consumption of sugar was 2,070,978 long tons; in 1907 it was 2,993,979 tons, an increase in ten years of 923,000 tons. During the same period the increase in domestic production has been only about 350,000 tons.

## SUGAR IMPORTED FOR CONSUMPTION.

The next table shows the character of the sugar imported for consumption, and its origin. Nearly 85 per cent of the sugar imported comes from Hawaii, Porto Rico, the Philippines, and Cuba under tariff concessions, while only about 15 per cent comes from other countries and pays full duty. The imports from both Porto Rico and Cuba are steadily increasing, Cuba alone furnishing about 58 per cent of the foreign sugar consumed in the United States in 1907, and about 45 per cent of the total sugar consumed. It will be noticed that nearly all the imported sugar consumed in the United States is made from cane; in 1906 less than 8 per cent was from beets, and in 1907 less than 1 per cent. In fact, if the sugar made in the United States be included, it appears that only about 13 per cent of the sugar consumed in this country in 1907 was made from beets.

*Consumption of imported sugar, 1905–1907.*

According to Willett & Gray.

| Kind and origin. | 1907. | 1906. | 1905. |
|---|---|---|---|
| Imports on which tariff concession is allowed:[a] | *Tons.*[b] | *Tons.*[b] | *Tons.*[b] |
| From Hawaii, cane sugar | 418,102 | 343,857 | 376,497 |
| From Porto Rico, cane sugar | 212,853 | 193,978 | 124,928 |
| From Philippines, cane sugar | 10,700 | 41,900 | 14,673 |
| From Cuba, cane sugar | 1,340,400 | 1,165,994 | 1,101,611 |
| Total | 1,982,055 | 1,745,729 | 1,617,709 |
| Imports on which full duty is assessed:[c] | | | |
| Foreign sugar— | | | |
| Raw cane | 347,509 | 357,057 | 412,560 |
| Raw beet | 6,780 | 175,827 | 22,161 |
| Refined beet | 949 | 2,734 | 1,844 |
| Refined cane | 59 | 252 | 1,818 |
| Total | 355,297 | 535,870 | 438,383 |

---

[a] Sugar from Hawaii and Porto Rico is admitted free of duty; that from the Philippines at 25 per cent below the regular rate, and that from Cuba, under the reciprocity treaty, at 20 per cent less than the regular rate.

[b] Tons of 2,240 pounds.

[c] The regular rates of duty on raw sugar vary from 95 cents to $1.75½ per hundred pounds, depending on the character of the product; the regular rate on refined sugar is $1.95 per hundred pounds.

## THE WORLD'S SUGAR CROP.

The following table was prepared in the Bureau of Statistic epartment of Agriculture, and published in Progress of the ıgar Industry in the United States in 1907. •

*Sugar production of the world, 1903–1907.*[a]

| Country. | 1903-4. | 1904-5. | 1905-6. | 1906-7. |
|---|---|---|---|---|
| CANE SUGAR. | | | | |
| ıited States: | *Tons.* | *Tons.* | *Tons.* | *Tons.* |
| Louisiana and Texas | 248,277 | 350,000 | 342,000 | 243,000 |
| Hawaii | 328,103 | 380,576 | 383,225 | 392,871 |
| Porto Rico | 130,000 | 145,000 | 213,000 | 210,000 |
| Total United States[b] | 706,380 | 875,576 | 938,225 | 845,871 |
| ba | 1,040,228 | 1,163,258 | 1,178,749 | 1,427,673 |
| her West Indies | 268,306 | 244,837 | 302,163 | 279,631 |
| xico | 107,547 | 107,038 | 107,529 | 108,000 |
| ıtral America | 21,450 | 19,768 | 18,516 | 19,000 |
| ıth America | 601,134 | 590,382 | 700,001 | 610,151 |
| Total America | 2,745,045 | 3,000,859 | 3,245,183 | 3,290,326 |
| ia | 2,876,671 | 3,333,672 | 2,926,209 | 3,455,446 |
| rica | 355,747 | 251,340 | 317,967 | 349,000 |
| eania | 163,328 | 216,213 | 230,000 | 249,000 |
| ırope | 28,000 | 18,592 | 15,722 | 16,400 |
| Total cane-sugar production | 6,168,791 | 6,820,676 | 6,735,081 | 7,360,172 |
| BEET SUGAR. | | | | |
| ıited States | 214,825 | 216,173 | 279,393 | 431,796 |
| nada | 6,710 | 8,034 | 11,419 | 11,367 |
| Total America | 221,535 | 224,207 | 290,812 | 443,163 |
| ırope: | | | | |
| Germany | 1,927,681 | 1,598,164 | 2,415,136 | 2,238,000 |
| Austria-Hungary | 1,167,959 | 889,373 | 1,509,870 | 1,344,000 |
| France | 804,308 | 622,422 | 1,089,684 | 756,000 |
| Russia | 1,206,907 | 953,626 | 968,000 | 1,470,000 |
| Belgium | 209,811 | 176,466 | 328,770 | 283,000 |
| Netherlands | 123,551 | 136,551 | 207,189 | 181,000 |
| Other countries | 441,116 | 332,098 | 415,000 | 445,000 |

## THE BEET-SUGAR INDUSTRY OF EUROPE.

The foregoing table shows the enormous proportions to which the t-sugar industry has developed throughout central Europe and ecially in Germany, Austria, and Russia. The following table tains additional data showing the magnitude of the industry:

*mber of factories, yield of beets per acre, and yield of sugar in the principal beet-sugar countries of Europe.*[a]

| Items. | Germany. | Austria-Hungary. | France. | Russia. | Belgium. | Holland. | Sweden. | Denmark. |
|---|---|---|---|---|---|---|---|---|
| grown in beets.. | 1,097,132 | 844,987 | 494,158 | 1,443,591 | 148,941 | 108,872 | 72,927 | 38,038 |
| tons per acre[b]. | 12.91 | 10.59 | 11.04 | 7.16 | 12.39 | 11.01 | 13.82 | 12.49 |
| r of factories... | 369 | 206 | 277 | 280 | 83 | 28 | 19 | 7 |
| tons worked factory.......... | 38,390 | 43,433 | 19,695 | 36,918 | 22,240 | 42,809 | 53,019 | 67,879 |
| tage of extraction of sugar........ | 15.52 | 14.91 | 13.42 | 14.03 | 15.25 | 14.71 | 15.64 | 13.98 |

[a] F. Sachs in La Sucrerie Belge, August, 1907. [b] Tons of 2,204 pounds.

## CONSUMPTION OF SUGAR IN EUROPE.

Mr. F. O. Licht, a high authority on European beet-sugar statistics, a report dated February 21, 1908, estimates the per capita consumption of sugar in European countries as follows:

*European per capita consumption of sugar for the year 1906-7.*

| | Pounds. |
|---|---|
| rmany | 40.92 |
| tria | 24.32 |
| nce | 36.05 |
| sia | 20.55 |
| lland | 41.40 |
| gium | 29.70 |
| nmark | 73.68 |
| eden and Norway | 47.88 |
| ly | 7.63 |
| umania | 7.83 |
| ain | 11.37 |
| Portugal and Madeira | 15.51 |
| England | 93.50 |
| Bulgaria | 7.98 |
| Greece | 10.16 |
| Servia | 6.92 |
| Turkey | 11.73 |
| Switzerland | 55.22 |
| All Europe | 31.61 |
| United States | 77.54 |

The foregoing table shows that the United States consumes more gar per capita than any other nation except England, the consumpon in this country being about two and a half times as much as for uropeans in general.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 54.

# OME COMMON BIRDS
## IN THEIR RELATION TO AGRICULTURE.

BY

F. E. L. BEAL, B. S.,
*Assistant in Charge Economic Ornithology, Biological Survey.*

[REVISED MARCH, 1904.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1904.

## LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Biological Survey,
*Washington, D. C., February 15, 190*

Sir: I have the honor to transmit herewith, and to recommend for publicati
new and revised edition of Farmers' Bulletin No. 54, Some Common Birds in Th
Relation to Agriculture, by F. E. L. Beal, Assistant in Charge of Economic O
thology, Biological Survey. The first edition of this bulletin has proved so pop
that since May, 1897, the date of publication, 330,000 copies have been distribut
Additional material on the food habits of several western birds is incorporated in t
present edition.

Respectfully,

C. Hart Merriam,
*Chief, Biological Surv*

Hon. James Wilson,
*Secretary of Agriculture.*

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# SOME COMMON BIRDS IN THEIR RELATION TO AGRICULTURE.

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## INTRODUCTION.

While it has long been known that birds play an important part in
lation to agriculture, there seems to be a tendency to dwell on the
rm they do rather than on the good. Whether a bird is injurious
beneficial depends almost entirely upon what it eats. In the case,
erefore, of species which are unusually abundant or which depend
part for subsistence upon the crops of the farmer, the character of
eir food often becomes a very practical question. If crows or black-
irds are seen in numbers about cornfields, or if woodpeckers are
oticed at work in an orchard, it is perhaps not surprising that they
re accused of doing harm. Careful investigation, however, often
hows that they are actually destroying noxious insects; and also that
ven those which do harm at one season may compensate for it by eat-
ng insect pests at another. Insects are eaten at all times by the
ajority of land birds. During the breeding season most kinds sub-
ist largely on this food, and rear their young exclusively upon it.
hen insects are unusually plentiful, they are eaten by many birds
hich ordinarily do not touch them. Even birds of prey resort to
is diet. When insects are more easily obtained than other fare, the
maller hawks and owls live on them almost entirely. This was well
ustrated during the plague of Rocky Mountain locusts in the West-
n States when it was found that locusts were eaten by nearly every
rd in the region, and that they formed almost the entire food of a
rge majority of the species.

Within certain limits birds feed upon the kind of food that is most
cessible. Thus, as a rule, insectivorous birds eat the insects that are
ost easily obtained, provided they do not have some peculiarly dis-
reeable property. It is not probable that a bird habitually passes
one kind of insect to look for another which is more appetizing; and
ere seems little evidence in support of the theory that the selection
food is restricted to any particular species of insect, for it is evi-
nt that a bird eats those which by its own method of seeking are
ost easily obtained. Thus, a ground-feeding bird eats the insects it

finds among the dead leaves and grass; a flycatcher, watching for its prey from some vantage point, captures entirely different kinds; and the woodpecker, and the warbler in the tree top select still others. It is thus apparent that a bird's diet is likely to be quite varied, and to differ at different seasons of the year.

In investigating the food habits of birds, field observation can be relied on to a limited extent only, for it is not always easy by watching to determine what a bird really eats. In order to be positive on this point it is necessary to examine the contents of the stomach. When birds are suspected of doing injury to field crops or fruit trees, a few individuals should be shot and their stomachs examined. This will show unmistakably whether or not the birds are guilty.

In response to a general demand for definite information regarding the food habits of our native birds, the Biological Survey of the Department of Agriculture has conducted for some years past a systematic investigation of the food of species which are believed to be of economic importance. Thousands of birds' stomachs have been carefully examined in the laboratory, and all the available data respecting the food of the various species have been brought together. The results of the investigations relating to birds of prey, based on an examination of nearly 3,000 stomachs, were published in 1893 in a special bulletin entitled "The Hawks and Owls of the United States." Many other species have been similarly studied and the results published, either in bulletins or as articles in the Yearbooks. The present bulletin contains abstracts of the results of food studies of about [illegible] grain and insect eating birds belonging to 14 different families.[a]

These species comprise among others the crow blackbirds and rice-birds, against which serious complaints have been made on account of the damage they do to corn, wheat, rice, and other crops; and also the cuckoos, grosbeaks, and thrashers, which are generally admitted to be beneficial, but whose true value as insect destroyers has not been fully appreciated. The practical value of birds in controlling insect pests should be more generally recognized. It may be an easy matter to exterminate the birds in an orchard or grain field, but it is an extremely difficult one to control the insect pests. It is certain, too, that the value of our native sparrows as weed destroyers is not appreciated.

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[a] The limits of this bulletin preclude giving more than a very brief statement regarding the food of each bird, but more detailed accounts of some of the species will be found in the following reports of the Biological Survey (formerly Division of Ornithology and Mammalogy): The Cuckoos—Bulletin No. 9, 1898, pp. 1-[illegible]; Crow—Bulletin No. 6, 1895, pp. 1-98; Woodpeckers—Bulletin No. 7, 1895, pp. 1-[illegible]; Kingbird—Annual Report Secretary of Agriculture for 1893, pp. 233-234; Redwinged Blackbird—Yearbook for 1897, pp. 349-351; Baltimore Oriole—Yearbook for [illegible], pp. 426-430; Grackles—Yearbook for 1894, pp. 233-248; Meadowlark—Yearbook for 1895, pp. 420-426; Cedarbird—Annual Report Secretary of Agriculture for 189[illegible], pp. 197-200; Catbird, Brown Thrasher, and Wren—Yearbook for 1895, pp. 405-418.

d seed forms an important item of the winter food of many of
e birds, and it is impossible to estimate the immense numbers of
ous weeds which are thus annually destroyed.

birds are protected and encouraged to nest about the farm and
en, they will do their share in destroying noxious insects and
ls. A few hours spent in putting up boxes for bluebirds, mar-
and wrens will prove a good investment. In many States birds
protected by law. It remains for agriculturists to see that
aws are observed.

### THE QUAIL OR BOBWHITE (Colinus virginianus).

ie quail of the North, or partridge of the South, and bobwhite of
ywhere, is a well-known bird throughout most of the United States
of the Rocky Mountains. In New England, owing to the high
em in which its flesh is held as food, which results in much hunt-
and to the severity of the winters, the bird is not abundant, or, at
t, only locally so. It often attains to a fair degree of plentifulness
l some unusually hard winter with an uncommon amount of snow
roys nearly the whole stock, owing to their food supply being
ed out of reach beneath the snow. Farther south, and in sections
re there is less snowfall, bobwhite thrives in spite of any degree
old. If the forces of nature were its only enemies in such locali-
it would seldom die except from old age. Ever since the first
ement of the country this bird has been held in great estimation
ı object of sport, and its flesh has been highly valued for food. It
remained for a later generation to determine that however useful
ay be for these two purposes, it is of far greater value when alive
roaming freely about the farm.

ie food of the quail has been carefully studied by Dr. Sylvester
ght Judd, of the Biological Survey, with results that will doubtless
rise many people. Speaking of 13 birds which he shot, he says:

> ese 13 had taken weed seed to the extent of 63 per cent of their food. Thirty-
> per cent was ragweed, 2 per cent tick-trefoil, partridge pea, and locust seeds,
> 3 per cent seeds of miscellaneous weeds such as pigweed, sheep sorrel, Pennsyl-
> persicaria, climbing false buckwheat, trumpet creeper, paspalum, jewel weed,
> pigeon grass. Though the stomachs and crops were not well filled, the birds
> eaten 5,582 weed seeds. One crop contained 400 pigweed seeds, another 500
> of ragweed. * * * One bobwhite, in addition to other food, had consumed
> eeds of sheep sorrel, another 640 seeds of pigeon grass, and several 50 to 100
> of jewel weed.[a]

bout 14 per cent of the quail's food for the year consists of animal
er (insects and their allies). Prominent among these are the
rado potato beetle, the striped squash beetle, the cotton boll wee-

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irds of a Maryland Farm, a local study of Economic Ornithology, by Sylvester
dd, Ph.D., Assistant, Biological Survey, 1902.

vil, the chinch bug, grasshoppers, cutworms, and other pests of agriculture. As the quail subsists on vegetable matter during the late fall, winter, and early spring, it is evident that during the height of the insect season it must feed almost entirely upon these creatures in order that they should constitute 14 per cent of its food. Professor Forbes of Illinois found one stomach nearly filled with chinch bugs. The large green tobacco worms are also eaten.

As a weed destroyer the quail has few, if any, superiors. Moreover, its habits are such that it is almost constantly on the ground, where it is brought in close contact with both weed seeds and ground-living insects. It is a good ranger, and, if undisturbed, will patrol every day all the fields in its vicinity as it searches for food. Take it all in all, there is no more valuable bird to be allowed alive and free upon the farm. Yet too many farmers value their quail only because they can kill them in the fall and sell their bodies for a few dollars.

### THE MOURNING DOVE (Zenaidura macroura).

The mourning dove is found throughout the United States, though not abundantly in New England. While by nature it lives in groves or open fields where there are a few trees, it also breeds on the bare prairie, where, in the absence of trees and bushes, it nests on the ground. Although fairly abundant in many parts of the country, it is not a rapid breeder, and where it is treated as game the stock is easily depleted. The dove rears but two young at a time, and even when more than one brood is raised in the year, it can by no means compete in fecundity with the quail, which raises from 12 to 20 young at a laying, and sometimes has two such in the course of the season.

The food of the dove consists of seeds of weeds, together with some grain. The examination of the contents of 237 stomachs shows that over 99 per cent of the food consists wholly of vegetable matter, less than 1 per cent being animal. Wheat, oats, rye, corn, barley, and buckwheat were found in 150 of the stomachs, and constituted 32 per cent of the total food. However, three-fourths of this amount was waste grain picked up in the fields after the harvesting was over. Of the various grains eaten, wheat is the favorite, and is almost the only one taken when in good condition. Most of it was eaten in the months of July and August. Corn, the second in amount, was all old, damaged grain, taken from the field after the harvest or from roads or stock yards in summer. The principal and almost constant diet, however, is the seeds of weeds. These are eaten at all seasons of the year. They constitute 64 per cent of the annual food supply, and show very little variation during any month. Some of the seeds eaten were so minute that it seemed that none but the smallest species of birds would eat them, and then only when driven to do so by lack other food. Some instances of the enormous numbers of seeds that ividual birds consumed will be of interest. In one stomach were nd 7,500 seeds of the yellow wood-sorrel (*Oxalis stricta*), in another 00 seeds of barn grass or foxtail (*Chætocloa*), and in a third the owing:

| | Seeds. |
|---|---|
| Slender paspalum (*Paspalum setaceum*) | 2,600 |
| Orange hawkweed (*Hieracium aurantiacum*) | 4,820 |
| Hoary vervain (*Verbena stricta*) | 950 |
| Carolina cranesbill (*Geranium carolinianum*) | 120 |
| Yellow wood-sorrel (*Oxalis stricta*) | 50 |
| Panic grass (*Panicum* sp.) | 620 |
| Other weeds of various kinds | 40 |
| Total | 9,200 |

None of the foregoing are useful plants, and most of them are xious weeds.

This record of weed destruction can hardly be excelled. The dove es not eat insect or other animal food so far as is known. The few ces of insects found in the stomachs are believed to be the remains weevils contained in seeds which the birds had eaten. In some tes the dove is treated as a game bird, with an open season. In lifornia doves may be shot from July 1 to February 15. In this e the season opens too soon, for the writer saw a dove sitting as e as August 12. It would seem that September 1 would be a better e to begin the shooting. In most parts of the country the dove uld be entirely protected, especially throughout the Mississippi lley, where weeds are produced in such abundance.

## THE CUCKOOS (Coccyzus americanus and C. erythrophthalmus).

Two species of cuckoos, the yellow-billed (fig. 1) and the black-billed, common in the United States east of the Plains, and a subspecies the yellow-billed extends westward to the Pacific. While the two cies are quite distinct, they do not differ greatly in food habits, l their economic status is practically the same.

An examination of 155 stomachs has shown that these cuckoos are ch given to eating caterpillars, and, unlike most birds, do not reject se covered with hair. In fact, cuckoos eat so many hairy caterars that the hairs pierce the inner lining of the stomach and remain re, so that when the stomach is opened and turned inside out, it ears to be lined with a thin coating of fur.

An examination of the stomachs of 46 black-billed cuckoos, taken ing the summer months, showed the remains of 906 caterpillars, 44 tles, 96 grasshoppers, 100 sawflies, 30 stink bugs, and 15 spiders. In probability more individuals than these were represented, but their ains were too badly broken for recognition. Most of the caterpillars were hairy, and many of them belonged to a genus that lives in colonies and feeds on the leaves of trees, including the apple tree. One stomach was filled with larvæ of a caterpillar belonging to the same genus as the tent caterpillar, while others contained that species. Other larvæ were those of large moths, for which the bird seems to have a special fondness. The beetles were mainly click beetles and weevils, with a few May beetles. The saw-flies were all found in two stomachs, one of which contained no less than 100 in the larval stage.

Of the yellow-billed cuckoo, 109 stomachs collected from May to October, inclusive, were examined. The contents consisted of 1,865 caterpillars, 93 beetles, 242 grasshoppers, 37 sawflies, 69 bugs, 6 flies, and 86 spiders. Most of the caterpillars belonged to hairy species and many of them were of large size. One stomach contained 250 American tent caterpillars; another 217 fall webworms. In places where tent caterpillars are abundant, they seem to constitute a large portion of the food of these two birds. The beetles were distributed among several families, but all were more or less harmful to agriculture. In the same stomach which contained the tent caterpillars were two Colorado potato beetles; in another were three goldsmith beetles and remains of several other large beetles. Besides grasshoppers there were several katydids and tree crickets. The sawflies were in the larval stage, in which they resemble caterpillars so closely that they are commonly called false caterpillars; and perhaps this likeness may be the reason the cuckoos eat them so freely. The bugs consisted of stink bugs and cicadas or dog-day harvest flies, with the single exception of one wheel bug, which was the only useful insect eaten, unless the spiders are counted as such.

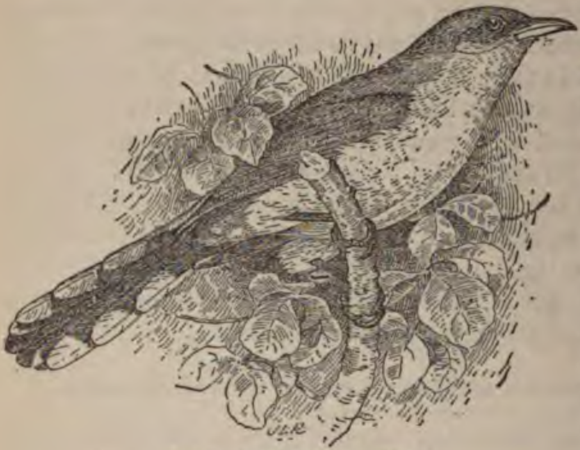
FIG. 1.—Yellow-billed cuckoo.

## THE WOODPECKERS.

Five or six species of woodpeckers are familiarly known throughout the eastern United States, and in the West are replaced by others of similar habits. Several species remain in the Northern States through the entire year, while others are more or less migratory.

armers are prone to look upon woodpeckers with suspicion. When birds are seen scrambling over fruit trees and pecking holes in the k, it is concluded that they are doing harm. Careful observers, ever, have noticed that, excepting a single species, these birds ely leave any conspicuous mark on a healthy tree, except when it ffected by wood-boring larvæ, which are accurately located, disged, and devoured by the woodpecker

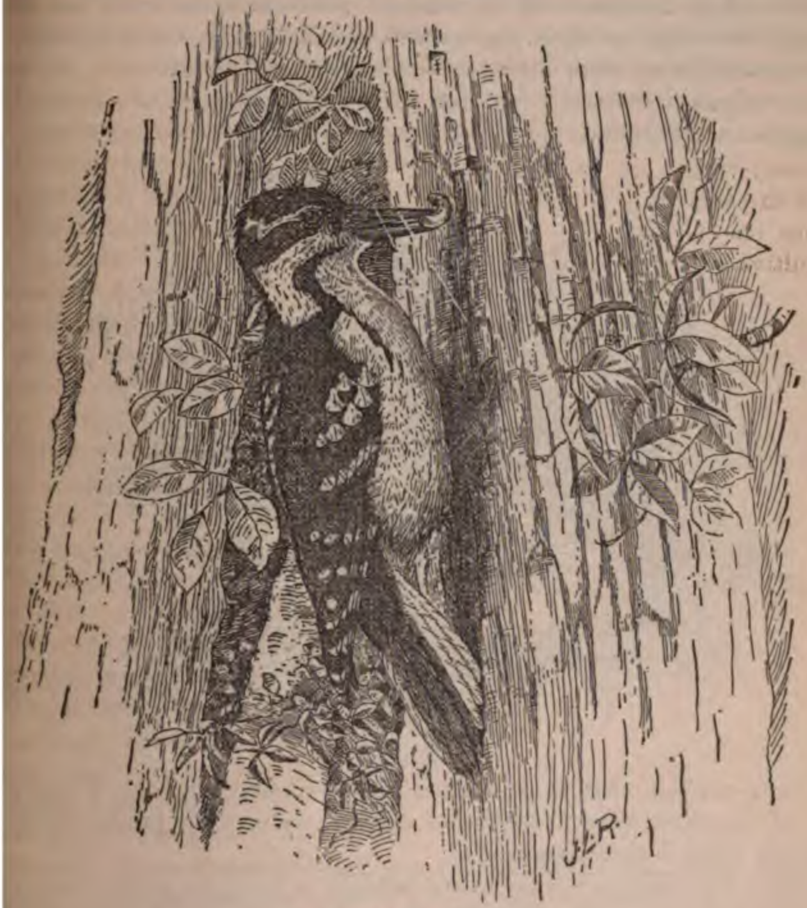

FIG. 2.—Hairy woodpecker.

Two of the best known woodpeckers, the hairy woodpecker (*Dryotes villosus*—fig. 2) and the downy woodpecker (*D. pubescens*), includg their races, range over the greater part of the United States. ey differ chiefly in size, their colors being practically the same. e males, like those of many other woodpeckers, are distinguished a scarlet patch on the head. An examination of many stomachs of ese two birds shows that from two-thirds to three-fourths of the

food consists of insects, chiefly noxious. Wood-boring beetles, bo
adults and larvæ, are conspicuous, and with them are associated ma
caterpillars, mostly species that burrow into trees. Next in imp
tance are the ants that live in decaying wood, all of which are so
by woodpeckers and eaten in great quantities. Many ants are p
ticularly harmful to timber, for if they find a small spot of decay
the vacant burrow of some woodborer, they enlarge the hole, and
their colony is always on the increase, continue to eat away the w
until the whole trunk is honeycombed. Moreover, these insects
not accessible to other birds, and could pursue their career of dest
tion unmolested were it not for the woodpeckers, whose beaks
tongues are especially fitted for digging out and devouring them.

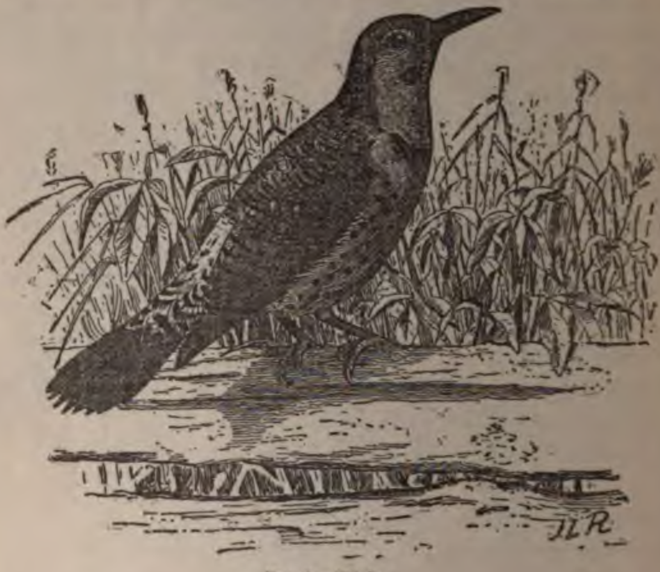

FIG. 3.—Flicker.

is thus evident that woodpeckers are great conservators of fo
To them, more than to any other agency, we owe the preservati
timber from destructive insects.

One of the larger woodpeckers familiar to everyone is the flick
golden-winged woodpecker (*Colaptes auratus*—fig. 3), which is g
ally distributed throughout the United States from the Atlantic Co
the Rocky Mountains. It is there replaced by the red-shafted fl
(*C. cafer collaris*), which extends westward to the Pacific. Th
species are as nearly identical in food habits as their respective env
ments will allow. The flickers, while genuine woodpeckers,
somewhat in habits from the rest of the family, and are frequ
seen searching for food upon the ground. Like the downy and
woodpeckers, they feed upon wood-boring grubs and ants, bu

ber of ants eaten is much greater than that eaten by the other two
ies. Of the flickers' stomachs examined, three were completely
d with ants. Two of these each contained more than 3,000 indi-
uals, while the third contained fully 5,000. These ants belong to
cies which live in the ground. It is these insects for which the
ker is searching when it runs about in the grass, although some
sshoppers also are then taken. The habit of the flicker of pecking
es in buildings sometimes greatly annoys his human friends. This
it is particularly noticeable in the California species. Observa-
n has shown that the object of the work is to obtain shelter for
winter. In the
st most of the
kers are migra-
y, and only a few
main at the North
here a shelter is
cessary. These
nerally find a safe
treat in the hol-
w tree in which
ey nested. In
alifornia, how-
er, where the
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East, and so
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isition and holes
e drilled, usually
der the eaves,
here a snug re-
eat for the night
found. Often a dozen holes may be seen in one building. Barns
other outbuildings are usually selected, though a church is some-
nes used.

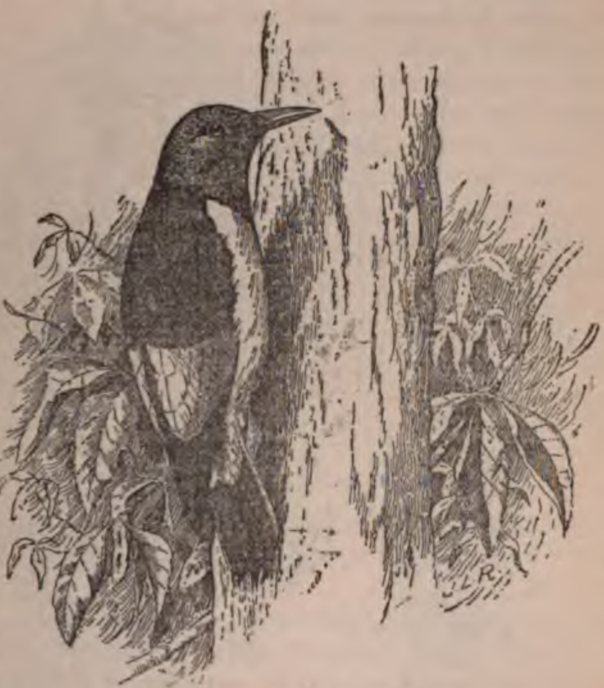

Fig. 4.—Red-headed woodpecker.

The red-headed woodpecker (*Melanerpes erythrocephalus*—fig. 4) is
ll known east of the Rocky Mountains, but is rather rare in New Eng-
d. Unlike some of the other species, it prefers fence posts and tele-
ph poles to trees as a foraging ground. Its food therefore natur-
y differs from that of the preceding species, and consists largely of
lt beetles and wasps, which it frequently captures on the wing, after
fashion of flycatchers. Grasshoppers also form an important part
the food. The redhead has a peculiar habit of selecting very large

considerable portion of its diet. In some cases the trees are injured by being thus punctured, and die in a year or two, but since comparatively few are touched, the damage is not great. It is probable, moreover, that the bird fully compensates for this injury by the insects it consumes.

The vegetable food of woodpeckers is varied, but consists largely of small fruits and berries. The downy and hairy woodpeckers eat such fruits as dogwood and Virginia creeper, together with the seeds of poison ivy, sumac, and a few other shrubs. The flicker also eats a great many small fruits and the seeds of a considerable number of shrubs and weeds. None of the three species is much given to eating cultivated fruits or crops. The redhead has been accused of eating the larger kinds of fruit, such as apples, and also of taking considerable corn. The stomach examinations show that to some extent these charges are substantiated, but that the habit is not prevalent enough to cause much damage. The bird is quite fond of mast, especially beechnuts, and when these nuts are plentiful it remains north all winter, instead of migrating, as is its usual custom. Half the food of the sapsucker, aside from sap, consists of vegetable matter, largely berries of the kinds already mentioned, and also a quantity of the inner bark of trees, more of which is eaten by this species than by any other.

The woodpeckers seem the only agents which can successfully cope with certain insect enemies of the forests, and, to some extent, with those of fruit trees also. For this reason, if for no other, they should be protected in every possible way.

### THE NIGHTHAWK (Chordeiles virginianus).

The nighthawk, or bull-bat, may be seen most often soaring high in air in the afternoon or early evening. It nests upon rocks or bare knolls and flat city roofs.

Its food consists of insects taken on the wing; and so greedy is the bird that when food is plentiful, it fills its great stomach almost to bursting. To ascertain the character of the food taken nearly 100 stomachs were examined, with interesting results. One of the most conspicuous elements was flying ants. Remains of these were found in 36 stomachs, in 24 of which the number ranged from 200 to 1,800. While ants have at times a useful function, they are for the most part annoying and harmful insects. It is evident that they would be much more numerous than they are were not their ranks so severely thinned by the attacks of the nighthawks. Moreover, these ants are killed at the most important epoch of their lives, when they are preparing to propagate their kind, and when the death of every female means the loss of hundreds, or perhaps thousands, of the next generation. In this work nighthawks rank next to, or even with, the woodpeckers, the acknowledged ant-eaters among birds. It is estimated that the 87 stomachs examined contained not less than 20,000 ants; and these were not half of the insect contents. Grasshoppers are another important article of the nighthawk's diet. One stomach contained the remains of 60 individuals, probably the refuse of several meals, as the jaws of the insects were the principal remains. Another stomach contained 38, another 22, and still another 19. The last were mostly entire. They serve to show how much the stomach of a nighthawk can hold. Many other stomachs contained smaller numbers of these insects. May-beetles (Lachnosterna) were found in a number of stomachs. One held the remains of 34, another 23, and a third 17. Several other stomachs contained less numbers. Besides these, many other injurious or annoying insects were found, but mostly in smaller quantities. One bird had eaten three Colorado potato beetles; several had taken both the striped and spotted squash beetles. Many other less known but injurious beetles were found, one stomach containing no less than 17 different species. Bugs of the chinch-bug family were found in very considerable numbers, though the chinch bug itself was not observed. Leaf hoppers were also eaten in considerable numbers. Many stomachs were nearly filled with some soft-bodied, dipterous insects, allied to mosquitoes, but not further identified.

From these glimpses of the food habits of the nighthawk it is evident that it is one of our most useful birds.

### THE KINGBIRD (Tyrannus tyrannus).

The kingbird (fig. 6) is essentially a lover of the orchard. It breeds in the States east of the Rocky Mountains, and less commonly in the Great Basin and on the Pacific coast. Its antipathy for hawks and crows is well known, and for this reason a family of kingbirds is a desirable adjunct to a poultry yard. On one occasion within the knowledge of the writer a hawk which attacked a brood of young turkeys was pounced upon and so severely buffeted by a pair of kingbirds whose nest was near by that the would-be robber was glad to escape without his prey. Song birds that nest near the kingbird are similarly protected.

In its food habits the kingbird is largely insectivorous. It is a true flycatcher by nature, and takes on the wing a large part of its food. It does not, however, confine itself to this method of hunting, but picks up some insects from trees and weeds, and even descends to the ground in search of myriapods or thousand legs. The chief complaint against the species is that it preys largely upon honeybees; and this charge is made by both professional bee keepers and others. One bee raiser in Iowa, suspecting the kingbirds of feeding upon his bees, shot a number near his hives; but when the stomachs of the birds were examined by an expert entomologist, not a trace of honeybees could be found.

An examination of 420 stomachs collected in various parts of the ntry was made by the Biological Survey, but only 14 were found contain remains of honeybees. In these 14 stomachs there were ll 50 honeybees, of which 40 were drones, 4 were certainly workers, the remaining 6 were too badly broken to be identified as to sex.

he insects that constitute the great bulk of the food of the bird are ious species, largely beetles—May beetles, click beetles (the larvæ which are known as wire worms), weevils, which prey upon fruit grain, and a host of others. Wasps, wild bees, and ants are concuous elements of the food, far outnumbering the hive bees. Dur- summer many grasshoppers and crickets, as well as leaf hoppers other bugs, are also eaten. Among the flies in the stomachs amined were a number of robber flies—insects which prey largely on other insects, especially honeybees, and which are known to comt in this way extensive depredations. It is thus evident that the gbird by destroying these es actually does good work r the apiarist. The nineteen bber flies found in the stomhs may be considered more an an equivalent for the four orker honeybees already menoned. A few caterpillars are ten, mostly belonging to the roup commonly known as cutorms, all the species of which e harmful. About 10 per cent the food consists of small tive fruits, comprising some enty common species of the adsides and thickets, such as gwood berries, elderberries, d wild grapes. The bird is not reported as eating cultivated fruit an injurious extent, and it is very doubtful if this is ever the case.

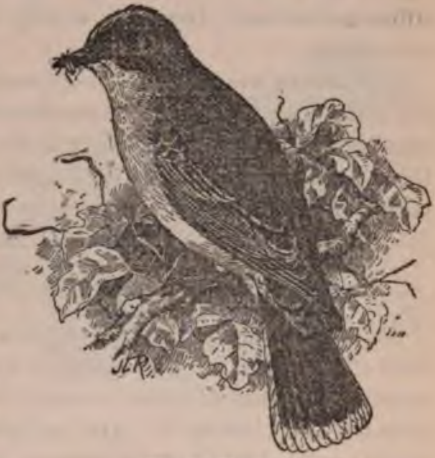

FIG. 6.—Kingbird.

Three points seem to be clearly established in regard to the food of e kingbird—(1) that about 90 per cent consists of insects, mostly jurious species; (2) that the alleged habit of preying upon honeyes is much less prevalent than has been supposed, and probably does t result in any great damage; and (3) that the vegetable food con sts almost entirely of wild fruits which have no economic value.

### THE ARKANSAS KINGBIRD (Tyrannus verticalis).

The Arkansas kingbird of the western United States is not so mestic in its habits as its eastern relative, preferring to live among e scattering oaks on the lonely hillside, rather than in the orchard about the ranch buildings. The work it does, however, in the destruction of noxious insects fully equals that of any member of its family. Like other flycatchers, it subsists mostly upon insects taken in mid-air, though it eats quite a number of grasshoppers that are probably taken from the ground. The bulk of its food consists of beetles, bugs (Hemiptera), wasps, and wild bees. Like its eastern representative, it has been accused of feeding to an injurious extent upon the honeybee. In an examination of 62 stomachs of this bird, great care was taken to identify every insect or fragment that had any resemblance to a honeybee; as a result, 30 honeybees (*Apis melifica*) were identified, of which 29 were males or drones and 1 was a worker. These were contained in four stomachs, and were the sole contents of three; in the fourth they constituted 99 per cent of the food. It is evident that the bee-eating habit is only occasional and accidental, rather than habitual; and it is also evident that if this ratio of drones to workers were maintained, the bird would be of more benefit than harm to the apiary.

The Cassin kingbird (*T. vociferans*) has a more southerly range than the Arkansas flycatcher. Examination of a number of stomachs shows that its food habits are similar to those of the others of the group. In their food habits, all of the kingbirds are of the greatest importance to the farmer and fruit grower, as they destroy vast numbers of harmful insects, and do no appreciable damage to any product of cultivation.

### THE PHŒBE (**Sayornis phœbe**).

Among the early spring arrivals at the North, none are more welcome than the phœbe (fig. 7). Though naturally building its nest under an overhanging cliff of rock or earth, or in the mouth of a cave, its preference for the vicinity of farm buildings is so marked that in the more thickly settled parts of the country the bird is seldom seen at any great distance from a farmhouse, except where a bridge spanning a stream affords a secure spot for a nest. Its confiding disposition renders it a great favorite, and consequently it is seldom disturbed. It breeds throughout the United States east of the Great Plains, and winters from the South Atlantic and Gulf States southward.

The phœbe subsists almost exclusively upon insects, most of which are caught upon the wing. An examination of 156 stomachs showed that over 93 per cent of the year's food consists of insects and spiders, while wild fruit constitutes the remainder. The insects belong chiefly to noxious species, and include many click beetles, May beetles, and weevils. In their season grasshoppers are eaten to a considerable extent, while wasps of various species, many flies of species that annoy cattle, and a few bugs and spiders are also eaten regularly. It is evident that a pair of phœbes must materially reduce the number of insects near a garden or field, as the birds often, if not always, raise two broods a year, and each brood numbers from four to six young.

There is hardly a more useful species about the farm than the phœbe, and it should receive every encouragement. To furnish nesting boxes is unnecessary, as it usually prefers a more open situation, like a shed, or a nook under the eaves, but it should be protected from cats and other marauders.

### THE BLACK PHŒBE (Sayornis nigricans semiatra).

The black phœbe is found from Texas west to the Pacific coast, which it occupies as far north as Washington, replacing through most of this region the common or eastern form. It has the same habits as the eastern phœbe, both as to its food and its selection of a nesting site, preferring for this purpose some structure of man, as a shed, or, better still, a bridge over a stream of water. The preference of the black phœbe for the vicinity of water is very pronounced. The observer will always find one at a stream or pool and often at a watering trough by the roadside. A careful study of the habits of the bird shows that it obtains a large portion of its food about wet places. While camping beside a stream in California the writer took some pains to observe the habits of the black phœbes. The nesting season was over and the birds had nothing to do but eat. This they appeared to be doing all the time. When first observed in the morning, at the first glimmer of daylight, a phœbe was always found flitting from rock to rock, although it was so dusky that the bird could hardly be seen. This activity was kept up all day. Even after supper was eaten and it was so dark that notes were written by the aid of the camp fire, the phœbe was still engaged at his work of insect collecting, though it was difficult to understand how it could catch insects when there was scarcely light enough to see the bird. It may not have been the same bird that worked from dawn to dusk, but there was some individual of the species always busy; and an exploration of the stream up and down showed that every portion of it was patrolled by a phœbe, and that each one apparently did not range over more than 12 or 13 rods of water, and that some times two or three would be seen near together.

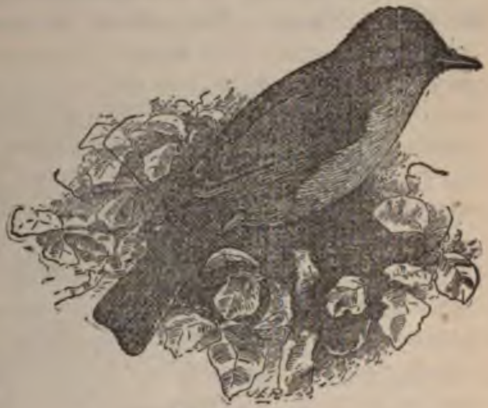

FIG. 7.—Phœbe.

This kind of observation alone is sufficient to convince any reasonable person that the number of insects destroyed in a year by the black phœbe is enormous. Fortunately, the examination of stomachs has supplemented observation in the field. Of the 119 stomachs examined, every one contained insects as the great bulk of the food. Only 15 contained any vegetable food at all, and in no case was it a considerable part of the contents of the stomach. The insects eaten were mostly wasps, bugs, and flies (Hymenoptera, Hemiptera, and Diptera), but many beetles were also destroyed. Grasshoppers did not appear, but a few traces of crickets were found. Dragon flies also were eaten. This last item illustrates the fondness of the species for the neighborhood of water. The vegetable matter eaten consisted chiefly of small wild fruits of no economic importance.

### THE BLUE JAY (Cyanocitta cristata).

The blue jay (fig. 8) is a common bird of the United States east of the Great Plains. Throughout the year it remains in most of its range, though in the Northern States its numbers are somewhat reduced in winter. During spring and summer the jay is forced to become an industrious hunter for insects, and is not so conspicuous a feature of the landscape as when it roams the country at will after the cares of the nesting season are over. Ornithologists and field observers in general declare that a considerable part of its food in spring and early summer consists of the eggs and young of small birds, and some farmers accuse it of stealing corn to an injurious extent in the fall. While doubtless there is much truth in these accusations, they have almost certainly been exaggerated.

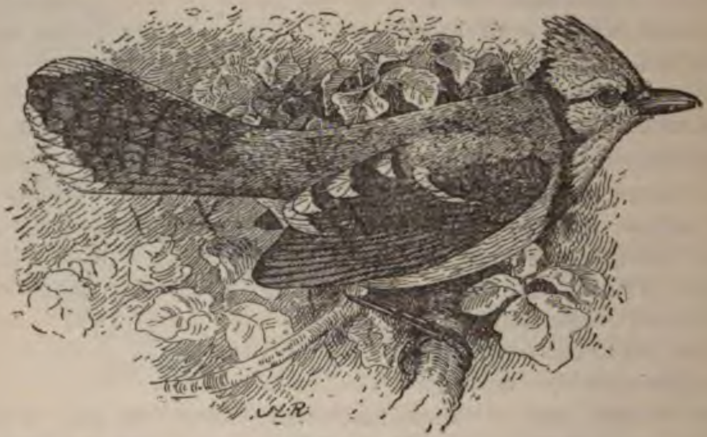

FIG. 8.—Blue jay.

In an investigation of the food of the blue jay 300 stomachs were examined, which showed that animal matter comprised 24 per cent and vegetable matter 76 per cent of the bird's diet. Special search was made for traces of birds or birds' eggs in the stomachs, with the result that shells of small birds' eggs were found in three and the remains of young birds in two. Such negative evidence is not sufficient to controvert the great mass of testimony upon this point, although it shows that the habit is not so widespread as believed. Besides birds and their eggs, the jay eats mice, fish, salamanders, snails, and crustaceans, which altogether constitute but little more than 1 per cent of its diet. The insect food is made up of beetles, grasshoppers, caterpillars, and a few species of other orders, all noxious, except some 3½ per cent of predaceous beetles. Thus something more than 19 per cent of the whole food consists of harmful insects. In August the jay, like many other birds, turns its attention to grasshoppers, which constitute during that month nearly one-fifth of its food. At this time, also, most of the other noxious insects, including caterpillars, are consumed, though beetles are eaten chiefly in spring.

The vegetable food is quite varied, but the item of most interest is grain. Corn was found in 70 stomachs, wheat in 8, and oats in 2—all constituting 19 per cent of the total food. Corn is evidently the favorite grain, but a closer inspection of the record shows that the greater part was eaten during the first five months of the year, and that very little was taken after May, even in harvest time, when it is abundant. This indicates that most of the corn is gleaned from the fields after harvest, except what is stolen from cribs or gathered in May at planting time.

The jay's favorite food is mast (i. e., acorns, chestnuts, chinquapins, etc.), which was found in 200 of the 300 stomachs, and amounted to more than 42 per cent of the whole food. In September corn formed 15 and mast 35 per cent, while in October, November, and December corn dropped to an almost inappreciable quantity and mast amounted to 64, 82, and 83 per cent in the three months, respectively. And yet in these months corn is abundant and everywhere easily accessible. The other elements of food consist of a few seeds and wild fruits, among which grapes and blackberries predominate.

### THE PACIFIC COAST JAYS (Aphelocoma californica and Cyanocitta stelleri).

In California and adjacent States two species of jays are much in evidence under several more or less well-marked forms. Steller's jay most resembles the eastern bird, but it is more shy and retiring, and seldom visits the orchard or vicinity of the ranch buildings. Stomach examination shows that its food does not differ radically from that of its eastern congener. As is the case with that bird, a very considerable part of the food consists of mast, together with a little fruit and some insects. The insects are largely wasps and also some beetles and grasshoppers. Besides mast, the jay eats some grain, which is probably waste or volunteer. So far as the writer knows, no complaints are made against this bird. Until it shall become less wary, it is not likely to trespass to a serious extent upon the farmer's preserve.

The California jay, although of a different genus, more nearly resembles its eastern relative in its food habits and actions. It freely visits the stock yards near the ranch buildings, and the orchards and gardens. As a fruit stealer it is notorious. On one occasion the writer shot seven jays from a prune tree, one after the other, leaving the dead bodies under the tree until all were killed. So eager were they to get the fruit that the report of the gun and the sight of their dead did not deter them from coming to the tree even before the fallen ones could be picked up. In orchards in canyons or on the hillsides adjacent to chaparral or other cover, great mischief is done by this bird. In one case, an orchard, situated on a piece of flat bottom land in a canyon just at the point where a small side canyon or ravine opened in, was under observation at a time when the prune crop was ripening. Jays in a continuous stream were seen to come down the small ravine to the orchard, prey upon the fruit, and return, in many cases each carrying off a prune.

Fruit stealing, however, is only one of the sins of the California jay. That it robs hens' nests of their eggs is the universal testimony. A woman who lived at the mouth of a small ravine told me that one of her hens had a nest under a clump of bushes. Every day a jay came to a tree a few rods away. When it heard the cackle of the hen announcing a new egg, it flew at once to the nest. At the same time the mistress of the house hastened to the spot to secure the prize, but in most cases the jay won the race and got the egg. This is only one of many similar cases recounted. The jays have learned just what the cackle of the hen means. Another case more serious is that related by a young man engaged in raising white leghorn fowls on a ranch several miles up a canyon. He says that when the chicks were very young the jays would attack and kill them by a few blows of the beak and then peck open the skull and eat out the brains. In spite of all the efforts to protect the chicks and kill the jays, the losses in this way were serious.

The examination of the stomachs of 141 California jays shows that 35 per cent of the contents for the year consists of animal matter and 65 per cent of vegetable. Although the great bulk of the animal food consists of insects, the remains of eggshells and birds' bones appear much too often. The insect food is fairly well distributed among the more common orders, but grasshoppers are slightly the most numerous and constitute 5 per cent of the year's food. In July, August, and September, however, the amount is 14, 18, and 19 per cent, respectively. Four per cent of the food consists of wasps, bees, *etc.*, but in the three months named they constitute 15, 7, and 9 per cent, respectively. A worker honeybee was found in each of two stomachs. It is rather surprising to find a bird like the jay eating so many of these active and elusive insects. One expects to find such insects in the diet of a flycatcher, but hardly in that of a jay. The remainder of the insect food is pretty evenly distributed among beetles, bugs, flies, and caterpillars. Eggshells were found in 21 stomachs and birds' bones in 5. Six stomachs contained the bones of mammals and 2 those of a lizard. No bird has a worse reputation for nest robbing than the eastern jay, and yet out of 300 stomachs of this species only 3 contained eggshells and 2 the bones of birds. This comparison serves to show what a marauder and nest thief the California jay really is.

In its vegetable diet this bird much resembles its eastern relative, the most remarkable difference being in the matter of fruit eating. With greater opportunities, the California bird has developed a greater appetite for fine fruit, and indulges it to the fullest extent. Remains of fruit were found in 114 of the 141 stomachs. The per cent for the year is only 16, but for the four months of June, July, August, and September it is 44, 33, 53, and 25, respectively. Cherries, apricots, and prunes are the favorites among the cultivated fruits. Elderberries are eaten to some extent. Grain, which was found in 48 stomachs, amounts to 6 per cent of the food of the year. Practically all of it was taken in the four months above mentioned, but it is not probable that much damage is done by the jay in this respect. The major part of the grain was oats. What was not the wild variety was probably simply scattered grain gleaned after the harvest. Mast is eaten by the California jay from September to March inclusive, and constitutes during most of that period one of the principal elements of its food. In this respect the bird shows a remarkable similarity to the eastern jay. A few weed seeds and other miscellaneous items make up the balance of the vegetable food.

In summing up from an economic point of view the character of the food of the California jay, it must be conceded that it is not all that could be wished. It is evident that the taste of the jay for birds' eggs and fine fruit is entirely too pronounced. That the bird will ever reform in the first respect is not to be hoped; in the case of the fruit stealing, it is probable that while it would not cease with a reduction of the bird's numbers, it would be so lessened as not to be noticeable. At the present time the species is superabundant in California. While the natural food supply of the bird has been lessened by bringing the woods and brushy canyons under cultivation, the same areas have been planted to fruit, and it is perfectly natural that this should be held by the jay as a legitimate source of food supply.

### THE CROW (Corvus americanus).

There are few birds so well known as the common crow. Unlike most other species, he does not seem to decrease in numbers as the country becomes more densely populated. The crow is commonly regarded as a blackleg and a thief. Without the dash and brilliancy of the jay, or the bold savagery of the hawk, he is accused of doing more mischief than either. That he does pull up sprouting corn, destroy chickens, and rob the nests of small birds has been repeatedly proved. Nor are these all of his sins. He is known to eat frogs, toads, salamanders, and some small snakes, all harmless creatures that do some good by eating insects. With so many charges against him, it may be well to show why he should not be utterly condemned.

The examination of a large number of stomachs shows that the bird's-nesting habit, as in the case of the jay, is not so universal as has been supposed. Neither are many toads and frogs eaten. As frogs are of no great practical value, their destruction is not a serious matter; but toads are very useful, and their consumption, so far as it goes, must be counted against the crow. Turtles, crayfishes, and snails, of which he eats quite a large number, may be considered neutral, while mice may be counted to his credit.

In his insect food, however, the crow makes amends for sins in the rest of his dietary, although even here the first item is against him. Predaceous beetles are eaten in some numbers throughout the season, but the number is not great. May beetles, "dor-bugs," or June bugs, and others of the same family constitute the principal food during spring and early summer, and are fed to the young in immense quantities. Other beetles, nearly all of a noxious character, are eaten to a considerable extent. Grasshoppers are first taken in May, but not in large numbers until August, when, as might be expected, they form the leading article of diet. This shows that the crow is no exception to the general rule that most birds subsist, to a large extent, upon grasshoppers in the month of August. Many bugs, some caterpillars, mostly cutworms, and some spiders are also eaten—all of them either harmful or neutral. Of the insect diet, Mr. E. A. Schwarz says: "The facts, on the whole, speak overwhelmingly in favor of the crow."

Probably the most important item in the vegetable food of the crow is corn. By pulling up the newly sprouted seeds, the bird renders himself extremely obnoxious. Observation and experiments with tame crows show that hard, dry corn is never eaten if anything else is to be had, and that if fed to nestlings it is soon disgorged. The reason crows resort to newly planted fields is that the kernels of corn are softened by the moisture of the earth, and probably become more palatable in the process of germination, which changes the starch of the grain to sugar. Crows eat corn extensively only when it has been softened by germination or partial decay, or before it is ripe and still "in the milk." Experience has shown that they may be prevented from pulling up young corn by tarring the seed, which not only saves the corn but forces them to turn their attention to insects. If they persist in eating green corn it is not so easy to prevent the damage; but no details of extensive injury in this way have yet been presented, and it is probable that no great harm has been done.

Crows eat fruit to some extent, but confine themselves for the most part to wild species, such as dogwood, sour gum, and seeds of the different kinds of sumac. They have also a habit of sampling almost everything which appears eatable, especially when food is scarce.

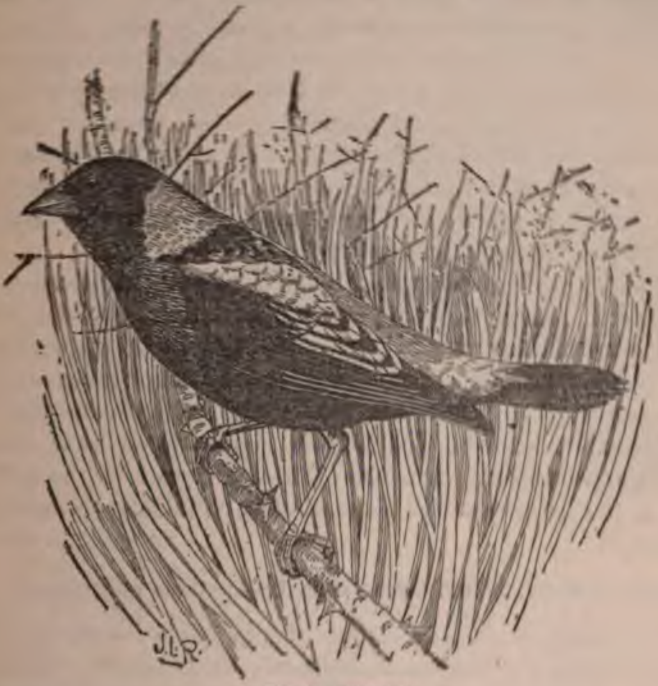

FIG. 9.—Bobolink.

In estimating the economic status of the crow, the bird should receive much credit for the insects which it destroys. In the more thickly settled parts of the country it probably does more good than harm, at least when ordinary precautions are taken to protect young poultry and newly planted corn against its depredations.

### THE BOBOLINK, OR RICEBIRD (*Dolichonyx oryzivorus*).

The bobolink (fig. 9) is a common summer resident of the United States, north of about latitude 40°, and from New England westward to the Great Plains, wintering beyond our southern border. In New England there are few birds, if any, around which so much romance clusters; in the South none on whose head so many maledictions are heaped. The bobolink, entering the United States from the south at a time when the rice fields are freshly sown, pulls up the young plants and feeds upon the seed. Its stay, however, is not long, and it soon hastens to the North, where it is welcomed as a herald of summer. During its sojourn in the Northern States it feeds mainly upon insects and small seeds of useless plants; but while rearing its young, insects constitute its chief food, and almost the exclusive diet of its brood. After the young are able to fly, the whole family gathers into a small flock and begins to live almost entirely upon vegetable food. This consists for the most part of weed seeds, since in the North these birds do not appear to attack grain to any great extent. They eat a few oats, but their stomachs do not reveal a great quantity of this or any other grain. As the season advances they gather into larger flocks and move southward, until by the end of August nearly all have left their breeding grounds. On their way they frequent the reedy marshes about the mouths of rivers and on the inland waters of the coast region, and subsist largely upon wild rice. After leaving the Northern States they are commonly known as reed birds, and becoming very fat are treated as game.

In the latter part of August the bobolinks begin to arrive on the rice fields, and during the next month make havoc in the ripening crop. It is unfortunate that the rice districts lie exactly in the track of their fall migration, since the abundant supply of food thus offered has undoubtedly served to attract them more and more, until most of the Northern-bred birds are concentrated with disastrous effect on the southeast coast when the rice ripens in the fall. The annual loss to rice growers on account of bobolinks has been estimated at $2,000,000.

### THE REDWINGED BLACKBIRD (Agelaius phœniceus).

The redwinged or swamp blackbird (fig. 10) is found all over the United States and the region immediately to the north. While common in most of its range, its distribution is more or less local, mainly on account of its partiality for swamps. Its nest is built near standing water, in tall grass, rushes, or bushes. Owing to this peculiarity the bird may be absent from large tracts of country which afford no swamps or marshes suitable for nesting. It usually breeds in large colonies, though single families, consisting of a male with several wives, may be found sometimes in a small slough, where each of the females builds her nest and rears her own little brood, while her liege lord displays his brilliant colors and struts in the sunshine. In the upper Mississippi Valley the species finds the conditions most favorable, for the countless prairie sloughs and the margins of the numerous shallow lakes afford nesting sites for thousands of redwings; and there are bred the immense flocks which sometimes do so much damage to the grain ields of the West. After the breeding season, the birds collect in locks to migrate, and remain thus associated throughout the winter.

Many complaints have been made against the redwing, and several States have placed at times a bounty upon its head. It is said to cause great damage to grain in the West, especially in the upper Mississippi Valley; and the rice growers of the South say that it eats rice. No complaints come from the northeastern part of the country, where the bird is much less abundant than in the West and South.

The examination of 1,083 stomachs showed that vegetable matter forms 74 per cent of the food, while the animal matter, mainly insects, forms but 26 per cent. A little more than 10 per cent consists of beetles, mostly harmful species. Weevils, or snout beetles, amount to 4 per cent of the year's food, but in June reach 25 per cent. As weevils are among the most harmful insects known, their destruction should condone for at least some of the sins of which the bird is accused. Grasshoppers constitute nearly 5 per cent of the food, while the rest of the animal matter is made up of various insects, a few snails, and crustaceans. The few dragon flies found were probably picked up dead, for they are too active to be taken alive, unless by a flycatcher. So far as the insect food as a whole is concerned, the redwing may be considered entirely beneficial.

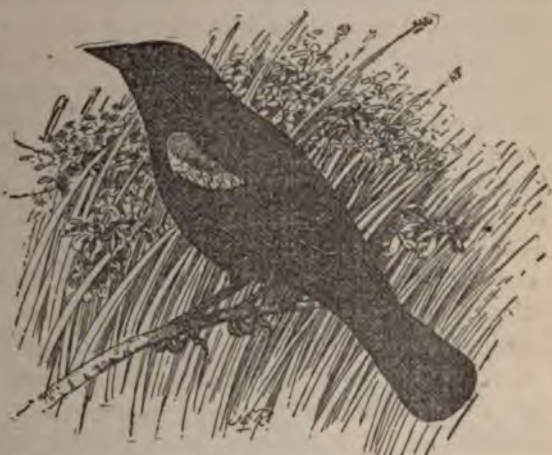

FIG. 10.—Redwinged blackbird.

The interest in the vegetable food of this bird centers around the grain. Only three kinds, corn, wheat, and oats, were found in appreciable quantities in the stomachs. They aggregate but little more than 13 per cent of the whole food, oats forming nearly half of this amount. In view of the many complaints that the redwing eats grain, this record is surprisingly small. The crow blackbird has been found to eat more than three times as much. In the case of the crow, corn forms one-fifth of the food, so that the redwinged blackbird, whose diet is made up of only a trifle more than one-eighth of grain, is really one of the least destructive species. The most important item of the bird's food, however, is weed seed, which forms practically the whole food in winter and about 57 per cent of the fare of the whole year. The principal weed seeds eaten are those of ragweed, barn grass, and smartweed. That these seeds are preferred is shown by the fact that the birds begin to eat them in August, when grain is still readily accessible, and continue feeding on them even after insects become plentiful in April. The redwing eats very little fruit and does practically no harm in the garden or orchard. Nearly seven-eighths of its food is made up of weed seed or of insects injurious to agriculture, indicating unmistakably that the bird should be protected, except, perhaps, in a few places where it is over abundant.

## THE MEADOWLARK (Sturnella magna).

The meadowlark (fig. 11) is a common and well-known bird occurring from the Atlantic coast to the Great Plains, where it gives way to a closely related subspecies, which extends thence westward to the Pacific. It winters from our southern border as far north as the District of Columbia, southern Illinois, and occasionally Iowa. Although it is a bird of the plains, and finds its most congenial haunts in the prairies of the West, it does not disdain the meadows and mowing lands of New England. It nests on the ground.

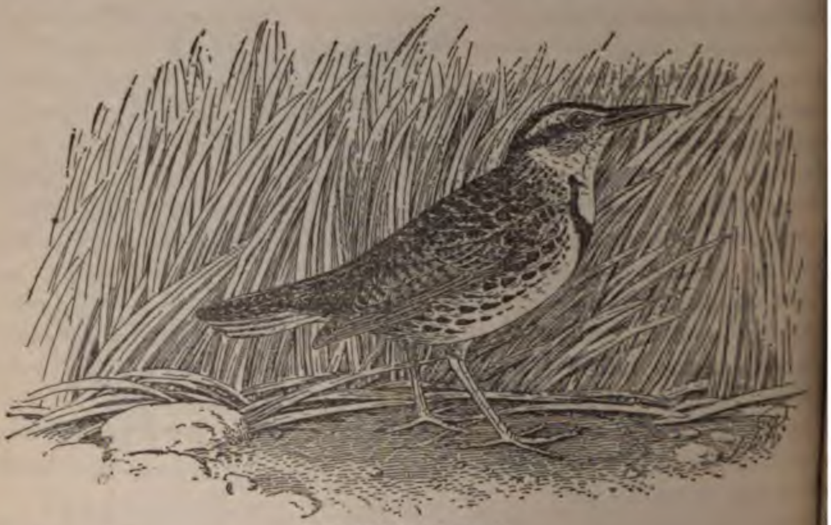

FIG. 11.—Meadowlark.

In the 285 stomachs examined, animal food (practically all insects) constituted 73 per cent of the contents, and vegetable matter 27 per cent. As would naturally be supposed, the insects were ground species, such as beetles, bugs, grasshoppers, and caterpillars, together with a few flies, wasps, and spiders. A number of the stomachs were taken from birds killed when the ground was covered with snow, but even these contained a large percentage of insects, showing the bird's skill in finding proper food under adverse circumstances.

Of the various insects eaten, crickets and grasshoppers are the most
portant, constituting 29 per cent of the food of the year and 69 per
t of the food in August. It is scarcely necessary to enlarge upon
s point, but the beneficial effect a number of these birds must have
a field of grass in the height of the grasshopper season can be readily
n. Of the 285 stomachs collected at all seasons of the year, 184,
nearly two-thirds, contained remains of grasshoppers, and one was
ed with fragments of 37 of these insects. This seems to show con-
sively that grasshoppers are preferred, and are eaten whenever
y can be found. The great number taken in August is especially
table. August is essentially the grasshopper month, i. e., the month
en grasshoppers reach their maximum abundance, and stomach
mination shows that a large number of birds resort at this time to
s diet, no matter what may be the food during the rest of the year.

Next to grasshoppers, beetles make up the most important item of
meadowlark's food, amounting to nearly 21 per cent, of which
out one-third are predaceous ground beetles. The others are all
rmful species. When it is considered that the bird feeds exclu-
ely on the ground, it seems remarkable that so few useful ground
tles are eaten. Many of the useful kinds have a disgusting odor,
l possibly this may occasionally save them from destruction by
ds, especially when other food is abundant. Caterpillars, too,
m a very constant element of the food, and in May constitute over
per cent of the whole. May is the month when the dreaded cutworm
gins its deadly career, and then the lark does some of its best work.
ost of these caterpillars are ground feeders, and are overlooked
birds which habitually frequent trees, but the meadowlark finds
d devours them by thousands. The remainder of the insect food
made up of a few ants, wasps, and spiders, with a few bugs, includ-
g some chinch bugs.

The vegetable food consists of grain, weed, and other hard seeds.
ain in general amounts to 14 per cent, and weed and other seeds to
per cent. Grain, principally corn, is eaten mostly in winter and
ly spring, and must be, therefore, simply waste kernels; only a trifle
consumed in summer and autumn, when it is most plentiful. No
ce of sprouting grain was discovered. Clover seed was found in
y six stomachs, and but little in each. Seeds of weeds, principally
gweed, barn grass, and smartweed, are eaten from November to
ril, inclusive, but during the rest of the year are replaced by insects.

Briefly stated, more than half of the meadow lark's food consists of
mful insects; its vegetable food is composed either of noxious weeds
waste grain, and the remainder is made up of useful beetles or neu-
l insects and spiders. A strong point in the bird's favor is that,
hough naturally an insect eater, it is able to subsist on vegetable
d, and consequently is not forced to migrate in cold weather farther
n is necessary to find ground free from snow.

## THE BALTIMORE ORIOLE (Icterus galbula).

Brilliancy of plumage, sweetness of song, and food habits to w
no exception can be taken are some of the striking characteristi
the Baltimore oriole (fig. 12). In summer it is found throughout
northern half of the United States east of the Great Plains. Its
commands hardly less admiration than the beauty of its plumag
the excellence of its song. Hanging from the tip of the outerm
bough of a stately elm, it is almost inaccessible, and so stron
fastened as to bid defiance to the elements.

Observation both in the field and laboratory shows that caterpill
constitute the largest item of the fare of the oriole. In 202 stoma
they formed 34 per cent of the food. They are eaten in vary
quantities during all the months in which the bird remains in
country. The fewest are eaten in July, when a little fruit is

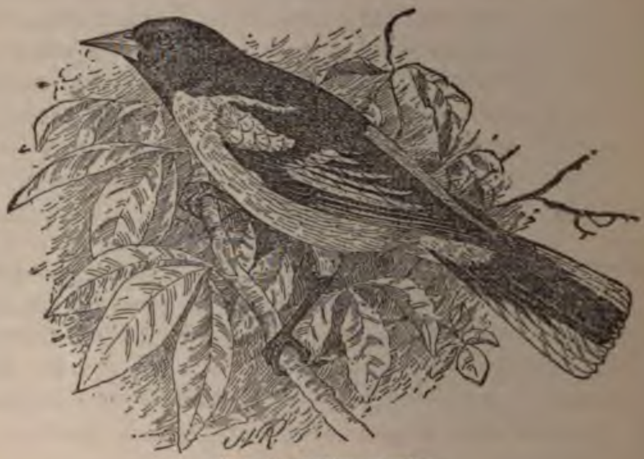

FIG. 12.—Baltimore oriole.

taken. The other insects consist of beetles, bugs, ants, wasps,
hoppers, and some spiders. The beetles are principally click b
the larvæ of which are among the most destructive insects k
and the bugs include plant and bark lice, both very harmful,
small and obscure as to be passed over unnoticed by most birds.
are eaten mostly in spring, grasshoppers in July and Augus
wasps and spiders with considerable regularity throughout the s

During the stay of the oriole in the United States, vegetable
amounts to only a little more than 16 per cent of the food of the
so that the possibility of its doing much damage to crops is
limited. It is accused of eating peas to a considerable exten
remains of such were found in only two stomachs. One write
that it damages grapes, but none were found.

### THE BULLOCK ORIOLE (Icterus bullocki).

The Bullock oriole is the western representative of the Baltimore iole, taking the place of that species throughout the Pacific coast gion. It does not differ essentially in its habits of nesting or in its od from its eastern relative, but it is less beautiful in plumage. The amination of 70 stomachs shows that 75 per cent of its food consists insects, mostly of a noxious character. Caterpillars constitute 26 per nt of the food, the rest being made up of wasps, grasshoppers, bugs emiptera), and a few beetles. Among the Hemiptera, perhaps the st interesting is the black olive scale (*Lecanium oleæ*), which was und in 17 stomachs and constituted nearly 7 per cent of the whole od. It is not surprising that these small creatures are eaten by small ds like the titmice, but they must have some very agreeable proper-s as food in order to attract birds like the oriole. The vegetable ntingent of the oriole's food is mostly fruit, especially in June and ly, when it takes kindly to cherries and apricots, and sometimes eats re than the fruit grower considers a fair share. However, no great mplaint is made against the bird, and it is probable that as a rule does not do any serious harm. With such a good record as an insect ter one can well afford to spare it a few cherries.

### THE CROW BLACKBIRD OR GRACKLE (Quiscalus quiscula).

The crow blackbird (fig. 13) in one or more of its subspecies is a amiliar object in all the States east of the Rocky Mountains. Through-ut the year it is resident as far north as southern Illinois, and in sum-ier extends its range into the British provinces. In the Mississippi alley it is one of the most abundant birds, preferring to nest in the rtificial groves and windbreaks near farms instead of in the natural timber" which it formerly used. It breeds also in parks and near uildings, often in considerable colonies. Farther east, in New England, it is only locally abundant, though frequently seen in migration. fter July it becomes very rare, or entirely disappears, owing to the ct that it collects in large flocks and retires to some quiet place where od is abundant and where it can remain undisturbed during the olting season; but in the latter days of August and throughout eptember it usually reappears in immense numbers before moving uthward.

The crow blackbird is accused of many sins, such as stealing grain nd fruit and robbing the nests of other birds; but the farmers do ot undertake a war of extermination against it, and for the most art allow it to nest undisturbed about their premises. An examina-on of 2,346 stomachs shows that nearly one-third of its food consists f insects, of which the greater part are injurious. The bird also eats a few snails, crayfishes, salamanders, small fish, and occasionally a mouse. The stomach contents do not indicate that it robs other birds' nests to any great extent, as remains of birds and birds' eggs amount to less than half of 1 per cent.

It is on account of its vegetable food that the grackle is most likely to be accused of doing damage. Grain is eaten during the whole year, and during only a short time in summer is other food attractive enough to induce the bird to alter its diet. The grain taken in the winter and spring months probably consists of waste kernels gathered from the stubble. The stomachs do not indicate that the bird pulls sprouting grain; but the wheat eaten in July and August and the corn eaten in the fall are probably taken from fields of standing grain. The total grain consumed during the year constitutes 45 per cent of the whole food, but it is safe to say that at least half is waste grain, and consequently of no value. Although the crow blackbird eats in their season a few cherries and blackberries, and in the fall some wild fruit, it apparently does no damage in this way.

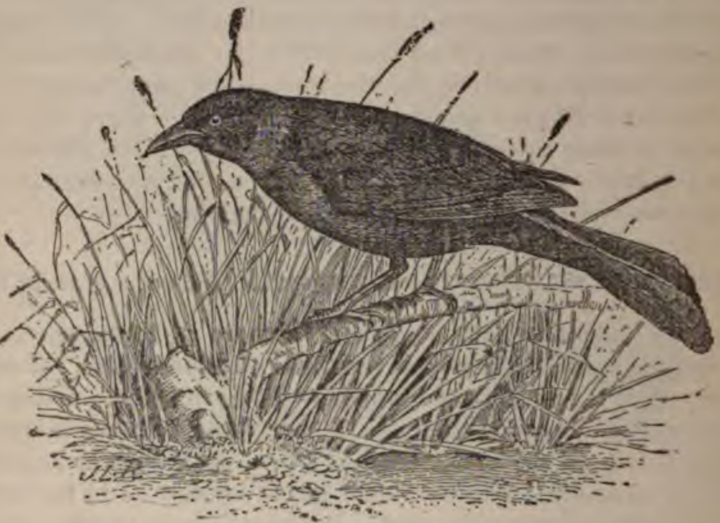

FIG. 13.—Crow blackbird.

Large flocks of crow blackbirds no doubt do considerable injury to grain crops; and there seems to be no remedy except the destruction of the birds, which is in itself expensive. During the breeding season, however, the species does much good by eating insects and by feeding them to its young, which are reared almost entirely upon this food. The bird does the greatest amount of good in spring, when it follows the plow in search of large grub-worms, of which it is so fond that it sometimes literally crams its stomach full of them.

## THE SPARROWS.[a]

Sparrows are not obtrusive birds, either in plumage, song, or action. ere are some forty species, with nearly as many subspecies, in North merica. Not more than half a dozen forms are generally known in y one locality. All the species are more or less migratory, but so dely are they distributed that there is probably no part of the coun- where some can not be found throughout the year.

While sparrows are noted seed eaters, they do not by any means nfine themselves to a vegetable diet. During the summer, and ecially in the breeding season, they eat many insects, and feed their ung largely upon the same food. An examination of the stomachs three species—the g sparrow (*Melos- a*), chipping spar- w (*Spizella socialis*), d field sparrow *izella pusilla*—fig. —shows that about e-third of the food nsists of insects, mprising many in- rious beetles, such snout-beetles or eevils, and leaf-bee- es. Many grass- ppers are eaten. In e case of the chip- ng sparrow, these in- cts form one-eighth the food. Grass- ppers would seem be rather large mor- ls, but the bird prob- ly confines itself to e smaller species; deed, this is indicated by the fact that the greatest amount (over 36 r cent) is eaten in June, when the larger species are still young and e smaller most numerous. Besides the insects already mentioned, any wasps and bugs are taken. Predaceous and parasitic Hymen- tera and predaceous beetles, all useful insects, are eaten only to a ght extent, so that as a whole the insect diet of the sparrows may considered beneficial.

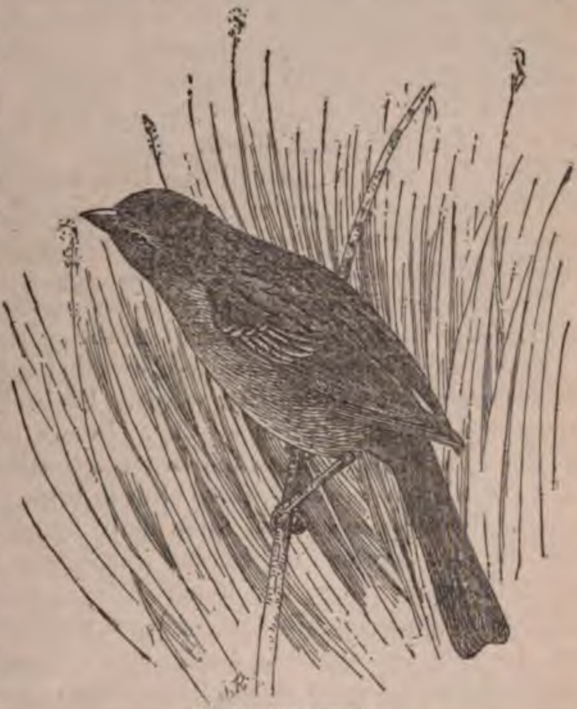

FIG. 14.—Field sparrow.

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[a] The sparrows here mentioned are all native species. For a full account of the glish sparrow, including its introduction, habits, and depredations, see Bul. No. 1 the Division of Ornithology, published in 1889.

Their vegetable food is limited almost exclusively to hard seeds. This might seem to indicate that the birds feed to some extent upon grain, but the stomachs examined show only one kind—oats—and but little of that. The great bulk of the food is made up of grass and weed seed, which form almost the entire diet during winter. The amount of these consumed is immense.

Anyone acquainted with the agricultural region of the Upper Mississippi Valley can not have failed to notice the enormous growth of weeds in every waste spot where the original sward has been disturbed. By the roadside, on the borders of cultivated fields, or in abandoned fields, wherever they can obtain a foothold, masses of rank weeds spring up and often form impenetrable thickets which afford food and shelter for immense numbers of birds and enable them to withstand great cold and the most terrible blizzards. A person visiting one of these weed patches on a sunny morning in January, when the thermometer is 20° or more below zero, will be struck with the life and animation of the busy little inhabitants. Instead of sitting forlorn and half frozen, they may be seen flitting from branch to branch, twittering and fluttering, and showing every evidence of enjoyment and perfect comfort. If one of them is shot, it will be found in excellent condition—in fact, a veritable ball of fat.

The snowbird (*Junco hyemalis*) and tree sparrow (*Spizella monticola*) are perhaps the most numerous of all the sparrows.

Examination of many stomachs shows that in winter the tree sparrow feeds entirely upon seeds of weeds. Probably each bird consumes about one-fourth of an ounce a day. In an article contributed in 1881 to the New York Tribune the writer estimated the amount of weed seed annually destroyed by these birds in Iowa. Upon the basis of one-fourth of an ounce of seed eaten daily by each bird, and supposing that the birds average ten to each square mile, and that they remain in their winter range two hundred days, we shall have a total of 1,750,000 pounds, or 875 tons, of weed seed consumed in a single season by this one species. Large as these figures may seem, they unquestionably fall far short of the reality. The estimate of ten birds to a square mile is much within the truth, for the tree sparrow is more abundant than this in winter in Massachusetts, where the food supply is less than in the Western States. The writer has known places in Iowa where several thousand tree sparrows could be seen within the space of a few acres. This estimate, moreover, is for a single species, while, as a matter of fact, there are at least half a dozen birds (not all sparrows) that habitually feed during winter on these seeds. Farther south the tree sparrow is replaced in winter by the white-throated sparrow, the white-crowned sparrow, the fox sparrow, the song sparrow, the field sparrow, and several others; so that all over the land a vast number of these seed eaters are at work during the colder months reducing next year's crop of worse than useless plants.

### THE HOUSE FINCH (Carpodacus mexicanus frontalis).

f all the sparrow group, there is probably no member, unless it the exotic form known as the English sparrow, that has by reason its food habits called down so many maledictions upon its head as house finch, red head, or linnet, as it is variously called. This d, like the other members of its family, is a seed eater by nature, before the beginning of fruit raising in California probably subed upon the seeds of weeds, with an occasional taste of some wild ry. Now, however, when orchards have extended throughout the gth and breadth of the State and every month from May to December some ripening fruit, the linnets take their share. As their name gion, the sum total of the fruit that they destroy is more than the t raiser feels that he can well spare. As the bird has a stout beak, as no difficulty in breaking the skin of the hardest fruit and feasting n the pulp, thereby spoiling the fruit and giving weaker-billed ds a chance to sample and acquire a taste for what they might otherwise have molested. Complaints against this bird have been ny and loud, more especially in the years when fruit crops first ame an important factor in the prosperity of the Pacific coast. At t time the various fruits presented to the linnets a new and easily tained food, while cultivation had reduced their formerly abundant pply of weed seed. When the early fruit growers saw their expected lden harvest suddenly snatched away, or at least much reduced in lue by the little marauders, it is no wonder that they were exasperd and wished to destroy utterly the authors of the mischief.

In order to test the matter thoroughly and ascertain whether these ds ate any other kind of food that might to some extent offset the mage that they inflicted upon the fruit, the horticulturists and ornilogists of California were requested to kill a number of the birds d send their stomachs to the Biological Survey. An agent was also t to the fruit-raising regions, who watched the birds in the orchards d collected a number of them. In this way 987 stomachs were obned and carefully examined, and the result shows that animal food sects) constituted 3.7 per cent, and vegetable food 96.3 per cent of stomach contents, not counting gravel.

So small a proportion of animal food does not of course admit of any at amount of insect destruction. As these stomachs were collected every month in the year, with the greater number taken during the nmer months, it is evident that whatever good one may hope to get m the linnet must not be looked for in this direction. Unlike most the sparrow family, the linnet does not feed its young upon insects any great extent. Quite a number of nestlings were dissected and contents of their stomachs carefully examined. The only animal d that was found consisted of woolly plant lice. These also conuted the great bulk of the animal food eaten by the adults.

The vegetable food of the species consists of three principal item grain, fruit, and weeds. Grain amounts to less than 1½ per cen August, which is the month of greatest consumption. The aver for the year is a trifle more than one-fourth of 1 per cent. F attains its maximum in September, when it amounts to 23 per cen the whole food. The average for the year is 9 per cent. The s of weeds constitute the bulk of the diet of the linnet. In Aug the month of least consumption, they amount to about 69 per cen the food. The average for the year is 87 per cent.

From the foregoing it is evident that whatever the linnet's sins be, grain eating is not one of them. In view of the great compl made against the linnet on the score of fruit eating, the small quan found in the stomachs taken is somewhat of a surprise. But it be remembered that the stomach contents do not tell the whole st When a bird takes a single peck from a cherry or apricot, it spoils whole fruit, and in this way may ruin half a dozen such in taki

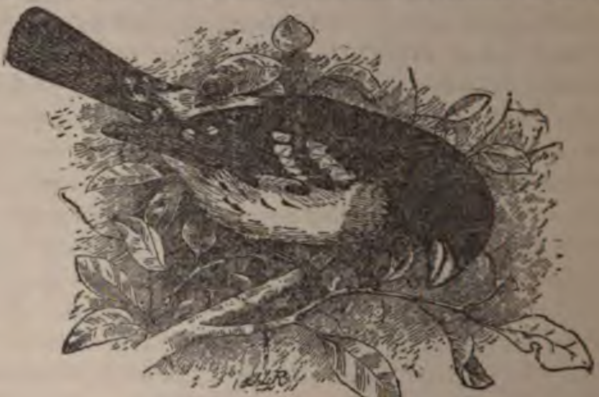

FIG. 15.—Rose-breasted grosbeak.

single meal. It is safe to say that the fruit pulp found in the stom does not represent more than one-fifth of what is actually destro That the linnets are persistent and voracious eaters of the early fru especially cherries and apricots, every fruit raiser in California bear testimony. That the damage is often serious no one will d It is noticed, however, that the earliest varieties are the ones affected; also, that in large orchards the damage is not noticed, in small plantations the whole crop is frequently destroyed.

### THE ROSE-BREASTED GROSBEAK (Zamelodia ludoviciana).

The beautiful rose-breasted grosbeak (fig. 15) breeds in the nort half of the United States east of the Missouri River, but spend winters beyond our boundaries. The beauty of the male is prover the fully adult bird is pure black and white, with a broad pat brilliant rose color upon the breast and under each wing.

When the Colorado potato beetle first swept over the land, and nat- alists and farmers were anxious to discover whether or not there were y enemies which would prey upon the pest, the grosbeak was almost only bird seen to eat the beetles. Further observation confirmed fact, and there can be no reasonable doubt that where the bird is ndant it has contributed very much to the abatement of the pest ich has been noted during the last decade. But this is not the only d which the bird does, for many other noxious insects besides the ato beetle are eaten.

he vegetable food of the grosbeak consists of buds and blossoms of est trees, and seeds, but the only damage of which it has been used is the stealing of green peas. The writer has observed it eat- peas and has examined the stomachs of several that were killed in very act. The stomachs contained a few peas and enough potato etles old and young, as well as other harmful insects, to pay for all the as the birds would be likely to eat in a whole season. The garden here this took place adjoined a small potato field which earlier in the ason was so badly infested with the beetles that the vines were com- etely riddled. The grosbeaks visited the field every day, and finally ought their fledged young. The young birds stood in a row on the pmost rail of the fence and were fed with the beetles which their rents gathered. When a careful inspection was made a few days ter, not a beetle, old or young, could be found; the birds had swept em from the field and saved the potatoes.

### THE BLACK-HEADED GROSBEAK (Zamelodia melanocephala).

The black-headed grosbeak is found over the whole Pacific coast d Rocky Mountain region, and takes the place filled by the rose- easted grosbeak in the eastern part of the United States. In its neral habits, including its food, it much resembles its eastern rela- e, though it lacks the latter's brilliant ornamentation on the breast d under the wings. Seventy stomachs of this bird have been exam- ed, showing 74 per cent of animal and 26 of vegetable food. Cater- lars constitute over 18 per cent of the food, a surprisingly large ount for such a stout-billed bird, which seems better adapted for ting nuts than such soft creatures as caterpillars. One interesting int may be noted in this connection. Thirty-five of the stomachs re from birds taken in an orchard infested with the codling moth. was a question whether the grosbeaks preyed upon this pest in any its forms. No moths or larvæ were detected, but pupæ were und and fully identified in 12 of the stomachs and amounted to 8 per ent of the food of the 35 birds. It is unfortunate that the codling oth in the adult form flies by night and in the larval form burrows once into the apple, so that it is protected from birds in both these ages. It pupates, however, in the crevices of the bark of the tree trunk, or on the ground in loose rubbish or clods of earth. latter state the birds find and destroy it.

Another element of the black-headed grosbeak's food that looked for in the stomach of so large and stout a bird was t olive scale. Of the 70 stomachs examined, 40 contained this to such an extent that it amounted to 15 per cent of the foo entire 70 birds. Beetles, mostly harmful species, were eate extent of 29 per cent. Prominent among these were the lon beetles, whose larvæ are largely borers in trees and other very harmful family of insects. Next in abundance are beetles, whose larvæ are commonly known as wireworms. in the ground and feed upon the roots and stalks of plant abundant, however, than either of the foregoing were the C lids, the leaf-eating beetles, which made up 23 per cent of t food. Some of the greatest insect pests are found in this fan as the Colorado potato beetle and the striped and spotte beetles. This last species is eaten freely by the grosbeak. found, with various other members of the family, in 46 stomachs. It has been shown that the rose-breasted grosbeal Colorado potato beetle whenever it is obtainable. It is prob if this insect should ever be introduced into California and t Pacific States, the black-headed grosbeak would be found re its part in keeping the pest within bounds.

The vegetable food of the bird consists largely of fruit, occasional kernel of grain or some other seed. But so far a no complaints have been made against the grosbeak on the eating fruit, and it is probable that what it does take is m paid for by the numbers of noxious insects which it destroys

## THE SWALLOWS.

There are seven common species of swallows within the the United States, four of which have abandoned to some ex primitive nesting habits and have attached themselves to the man.

In the eastern part of the country the barn swallow *erythrogastra*—fig. 16) now builds exclusively under roof entirely abandoned the rock caves and cliffs in which it former More recently the cliff swallow (*Petrochelidon lunifrons*) ha better nesting site under the eaves of buildings than was af the overhanging cliffs of earth or stone which it once us which it still resorts occasionally in the East, and habitua unsettled West. The martin (*Progne subis*) and the whi swallow (*Iridoprocne bicolor*) nest either in houses supplie purpose, in abandoned nests of woodpeckers, or in natural c rocks.

Field observation will convince an ordinarily attentive person that the food of swallows must consist of the smaller insects captured in mid-air, or perhaps in some cases picked from the tops of tall grass or weeds. This observation is borne out by an examination of stomachs, which shows that the food consists of many small species of beetles which are much on the wing; many species of Diptera (mosquitoes and their allies), together with large quantities of flying ants and a few insects of similar kinds. Most of these are either injurious or annoying, and the numbers destroyed by swallows are not only beyond calculation, but almost beyond imagination.

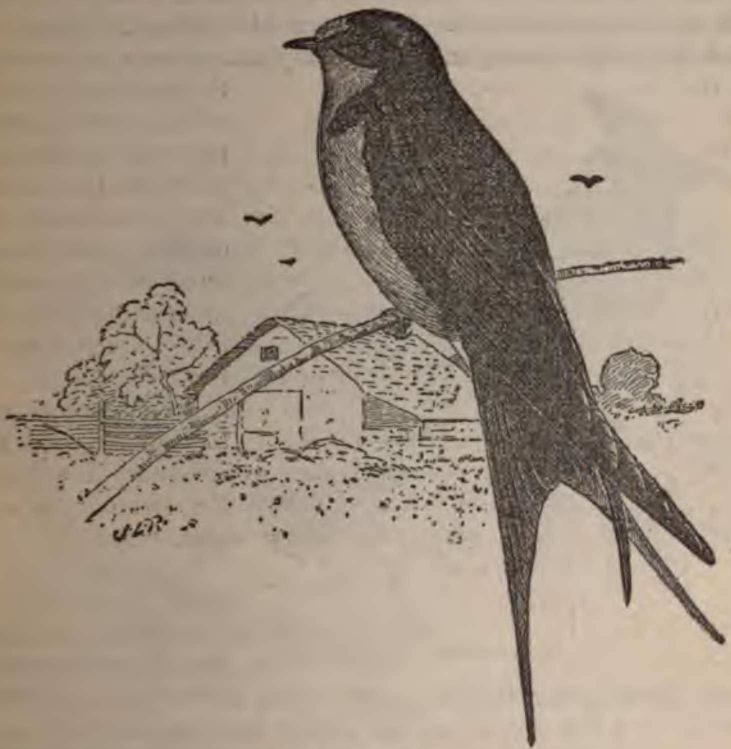

FIG. 16.—Barn swallow.

Unlike many other groups of birds the six species of swallows found in the Eastern States extend in a practically unchanged form across the continent to the Pacific coast, where they are reinforced by another species, the violet green swallow (*Tachycineta thalassina lepida*).

It is a mistake to tear down from the eaves of a barn the nests of a colony of cliff swallows, for so far from disfiguring a building they make a picturesque addition to it. The presence of swallows should be encouraged by every device. It is said that cliff and barn swallows may be induced to build their nests in a particular locality, otherw suitable, by providing a quantity of mud to be used by them as mortar. Barn swallows may also be encouraged by cutting a small hole in the gable of the barn, while martins and white-bellied swallows will be grateful for boxes like those for the bluebird, but placed in some higher situation.

### THE CEDARBIRD (Ampelis cedrorum).

The cedar waxwing, or cherry bird (fig. 17), inhabits the whole of the United States, but is much less common in the West. Although the great bulk of the species retires southward in winter, the bird is occasionally found in every State during the colder months, especially if wild berries are abundant. Its proverbial fondness for cherries has given it its popular name, and much complaint is made on account of the fruit it eats. Observation shows, however, that its depredations are confined to trees on which the fruit ripens earliest, while later varieties are comparatively untouched. This is probably due to the fact that when wild fruits ripen they are preferred to cherries, and really constitute the bulk of the diet of the cedarbird.

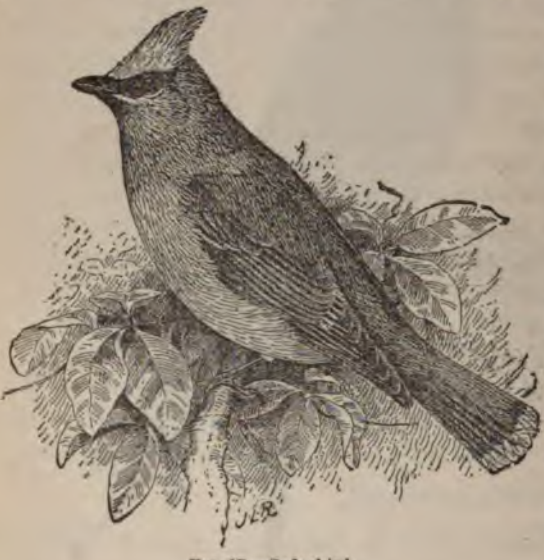

Fig. 17.—Cedarbird.

In 152 stomachs examined animal matter formed only 13 per cent and vegetable matter 87 per cent, showing that the bird is not wholly a fruit eater. With the exception of a few snails, all the animal food consisted of insects, mainly beetles—all but one more or less noxious, the famous elm leaf beetle being among the number. Bark or scale lice were found in several stomachs, while the rest of the animal food was made up of grasshoppers, bugs, and the like. Three nestlings had been fed almost entirely on insects.

Of the 87 per cent of vegetable food, 74 per cent consisted entirely of wild fruit or seeds and 13 of cultivated fruit, though a large part of the latter was made up of blackberries and raspberries, which may or may not have represented cultivated varieties. Cherry stealing is the chief complaint against this bird, but of the 152 stomachs only 9, all taken in June and July, contained any remains of cultivated cher-

, and these aggregated but 5 per cent of the year's food. As 41 nachs were collected in these months, it is evident that the birds not live to any great extent on cultivated cherries.

lthough the cherry bird is not a great insect destroyer, it does ne good work in this way, since it probably rears its young mostly n insect food. On the other hand, it does not devour nearly as ch cultivated fruit as has been asserted. Most, if not all, of the nage can doubtless be prevented by planting near garden or orchard h trees as the Russian mulberry, whose fruit attracts so many birds.

### THE CATBIRD (Galeoscoptes carolinensis).

he catbird (fig. 18), like the thrasher, is a lover of swamps, and ghts to make its home in a tangle of wild grapevines, greenbriers,

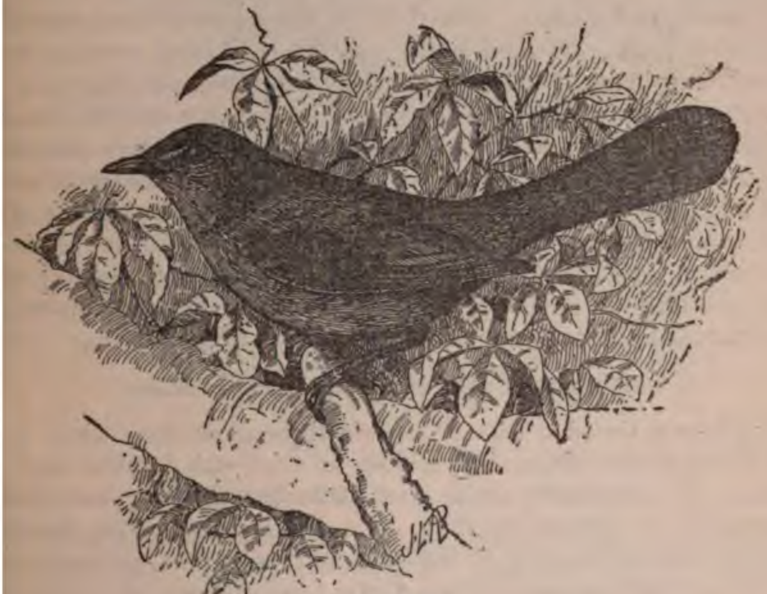

Fig. 18.—Catbird.

shrubs, where it is safe from attack and can find its favorite food bundance. It is found throughout the United States west to the ky Mountains, and occurs also in Washington, Idaho, and Utah, extends northward into the British provinces. It winters in the thern States, Cuba, Mexico, and Central America.

eports from the Mississippi Valley indicate that the catbird is etimes a serious annoyance to fruit growers. The reason for such orts may possibly be found in the fact that on the prairies fruitring shrubs, which afford so large a part of this bird's food, are picuously absent. With the settlement of this region comes an nsive planting of orchards, vineyards, and small-fruit gardens, which furnish shelter and nesting sites for the catbird, as well as for other species. There is in consequence a large increase in the numbers of the birds, but no corresponding gain in the supply of native fruits upon which they were accustomed to feed. Under these circumstances, what is more natural than for the birds to turn to cultivated fruits for their food? The remedy is obvious; cultivated fruits can be protected by the simple expedient of planting the wild species which are preferred by the birds. Some experiments with catbirds in captivity show that the Russian mulberry is preferred to any cultivated fruit that can be offered.

The stomachs of 213 catbirds were examined and found to contain 44 per cent of animal (insect) and 56 per cent of vegetable food.[a] Ants, beetles, caterpillars, and grasshoppers constitute three-fourths of the animal food, the remainder being made up of bugs, miscellaneous insects, and spiders. One-third of the vegetable food consists of cultivated fruits, or those which may be cultivated, such as strawberries, raspberries, and blackberries; but while we debit the bird with the whole of this, it is probable—and in the eastern and well-wooded part of the country almost certain—that a large part is obtained from wild vines. The rest of the vegetable matter is mostly wild fruit, such as cherries, dogwood, sour gum, elder berries, green brier, spice berries, black alder, sumac, and poison ivy. Although the catbird sometimes does considerable harm by destroying small fruit, the bird can not be considered injurious. On the contrary, in most parts of the country it does far more good than harm.

### THE BROWN THRASHER (Toxostoma rufum).

The brown thrasher (fig. 19) breeds throughout the United States east of the Great Plains, and winters in the South Atlantic and Gulf States. It occasionally visits the garden or orchard, but nests in swamps or in groves standing upon low ground. The thrasher's favorite time for singing is the early morning, when, perched on the top of some tall bush or low tree it gives an exhibition of vocal powers which would do credit to a mocking bird. Indeed, in the South, where the latter bird is abundant, the thrasher is known as the sandy mocker.

The food of the brown thrasher consists of both fruit and insects. An examination of 121 stomachs showed 36 per cent of vegetable and 64 of animal food, practically all insects, mostly taken in spring before fruit was ripe. Half the insects were beetles, and the remainder chiefly grasshoppers, caterpillars, bugs, and spiders. A few predaceous beetles were eaten, but on the whole the work of the species as an insect destroyer may be considered beneficial.

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[a] The investigation of the food of the catbird, brown thrasher, and house wren was made by Dr. Sylvester D. Judd and published in the Yearbook of the Department of Agriculture for 1895, pp. 405–408.

Eight per cent of its food is made up of fruits like raspberries and currants which are or may be cultivated, but the raspberries at least are as likely to belong to wild as to cultivated varieties. Grain, made up mostly of scattered kernels of oats and corn, is merely a trifle, amounting to only 3 per cent. Though some of the corn may be taken from newly-planted fields, it is amply paid for by the May beetles which are eaten at the same time by the bird. The rest of the food consists of wild fruit or seeds. Taken all in all, the brown thrasher is a useful bird, and probably does as good work in its secluded retreats as it would about the garden, for the swamps and groves are no doubt the breeding grounds of many insects that migrate thence to attack the crops of the farmer.

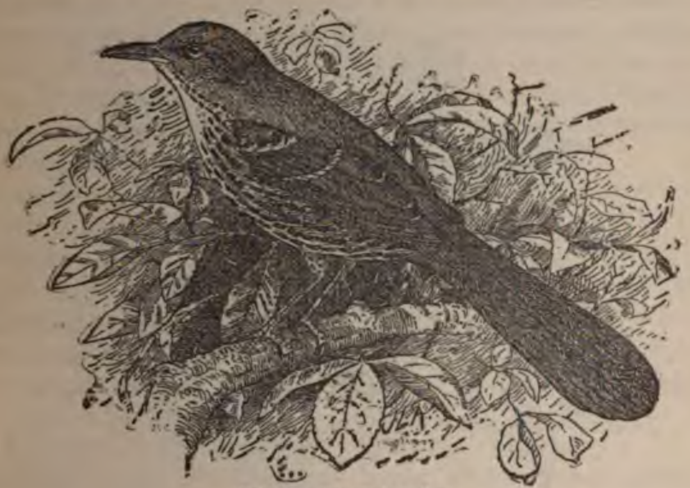

FIG. 19.—Brown thrasher.

## THE HOUSE WREN (Troglodytes aëdon).

The diminutive house wren (fig. 20) frequents barns and gardens, and particularly old orchards in which the trees are partially decayed. He makes his nest in a hollow branch where perhaps a woodpecker had a domicile the year before, but he is a pugnacious character, and if he happens to fancy one of the boxes that are put up for bluebirds, he does not hesitate to take it. He is usually not slow to avail himself of boxes, gourds, tin cans, or empty jars placed for his accommodation.

As regards food habits, the house wren is entirely beneficial. Practically, he may be said to live upon animal food alone, for an examination of 52 stomachs showed that 98 per cent of the contents was made up of insects or their allies, and only 2 per cent was vegetable food, including bits of grass and similar matter, evidently taken by accident with the insects. Half of this food consisted of grasshoppers and beetles; the remainder of caterpillars, bugs, and spiders house wren is a prolific breeder, frequently rearing in a season from twelve to sixteen young, a family of these birds must cause considerable reduction in the number of insects in a garden. Wrens are industrious foragers, searching every tree, shrub, or vine for caterpillars, examining every post and rail of the fence, and every cranny in the wall for insects or spiders.

### THE TITMICE.

The birds of the titmouse family, though insignificant in size, are far from being so in the matter of their food habits. What they lack in size of body, they more than make up for in numbers of individuals. While in the case of some of the larger birds, as, for instance, the flicker, there is one pair of eyes to look for food for one large stomach, we have in the case of the ten times as numerous titmice an equivalent stomach capacity divided by ten, and each portion furnished with a pair of eyes, and other accessories, such as wings and feet. As against the one place occupied by the larger bird, ten are being searched for food at the same time by the smaller species. It is evident that this arrangement is more effective in insect destruction than the plan of a single large bird.

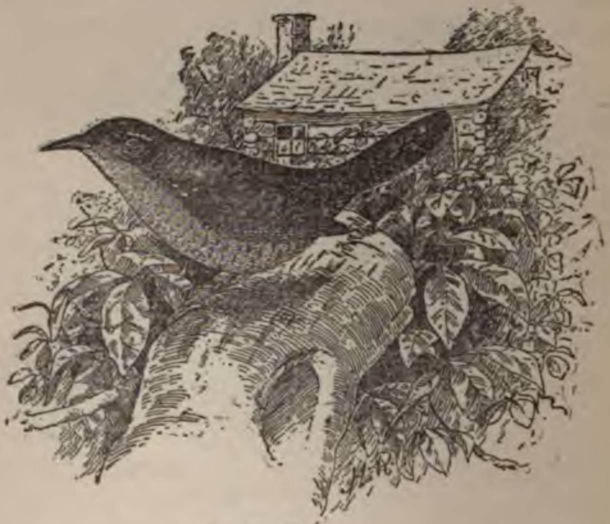

FIG. 20.—House wren.

The character of the food of the titmice gives a peculiar value to their services, for it consists largely of the smaller insects and their eggs, objects that either escape the search of the larger birds or are too insignificant to be considered worthy of notice. Throughout the year most of the species of this group remain on their range, so that they are constantly engaged in their beneficial work, continuing it in r when the majority of their coworkers have fled to a milder

It is at this season that the titmice do their greatest good, for flying and crawling insects are no more to be found, the birds feed upon such hibernating species as they find concealed in es or upon the eggs of insects laid in similar places. Little ion is necessary to convince one that in the winter dearth of g insects, the search for such available food as may be found e thorough and unremitting.

re are within the boundaries of the United States some 17 species nice, with nearly as many races or subspecies, so that there is no n of the country that does not have one or more forms. The rn coast region is peculiarly rich in representatives of this family. eastern portion of the country the best-known and most widely uted species is the common black-capped chickadee (*Parus atri-* *us*). This bird, or some of its subspecies, occupies the whole of art of the United States north of the latitude of Washington, tends into Canada. It is a prolific breeder, usually rearing from young in a brood.

examination of 289 stomachs of the chickadee shows that its onsists of 68 per cent of animal matter (insects), and 32 per cent etable matter. The former is made up of small caterpillars, and and their eggs. Prominent among the latter are the eggs of the aterpillar moths, both the orchard and forest species (*Clisiocampa* *cana* and *C. disstria*). As these are two of our most destructive s, the good done by the chickadee in devouring their eggs needs nment. During the winter months, the chickadee's food is made larvæ, chrysalids, and eggs of moths, varied by a few seeds, spring brings out hordes of flying, crawling, and jumping in- the bird varies its diet by taking also some of these. Flies and (*Diptera* and *Hemiptera*) are the favorites until the weather es quite warm, when beetles and small wasps are also taken. g the bugs may be mentioned the plant lice and their eggs which ten in winter. The beetles nearly all belong to the group of ophora, or snout beetles, more commonly known as weevils. insects are mostly of small size, and nearly all of them are as pests by the farmer or fruit raiser. Seventeen of them were in one stomach. The plum curculio and the cotton boll weevil e taken as fair samples. Grasshoppers do not at any time consti- n important element of the food of the chickadee as they are tly too large for so small a bird; moreover they are for the most errestrial insects, while the bird is essentially arboreal. Small and ants are eaten to some extent. Spiders constitute quite an tant element of the food and are eaten at all times of the year. irds evidently find them hibernating in winter as well as active mer. The vegetable food of the chickadee consists largely of small seeds, except in summer when they are replaced by pulp of wild fruit. The wax from the seeds of poison ivy (*Rhus radicans*) is eaten during the winter months, but the seeds themselves are not taken. In this respect the chickadees differ from most other birds which swallow the seeds whole, and after digesting the wax, pass them through the alimentary canal, and so scatter them broadcast to reproduce the noxious plants.

In the southern part of the country, the Carolina chickadee and the tufted tit replace the black-cap, but their food habits are so similar that there is no practical difference in the work done. In the West several other species occur; one of the most interesting of these is the bush tit (*Psaltriparus minimus*) which, with several subspecies, occupies the whole Pacific Coast region. They are minute, active, social little creatures which, except for a short time during the breeding season, are found in flocks, flitting from tree to tree, busily hunting for insects and their eggs. The contents of 66 stomachs of these birds, which were examined, were found to consist mostly of injurious insects to the extent of 83 per cent. Of these the most important was a small Hemipterous insect (*Nysius angustatus*), which amounted to more than half of the whole stomach contents. These insects are of considerable economic importance, as they frequently infest grapevines and other plants to a harmful extent. Several of the stomachs were almost exclusively filled with these minute creatures, some containing as many as 100 individuals.

Perhaps the most important and interesting insect found was the black olive scale (*Lecanium oleæ*), which occured in 24 stomachs and amounted to a little more than 18 per cent of the food. In addition a number of the stomachs were more or less filled with another scale, which was not further identified. A number of small snout beetles (weevils) were eaten and some small caterpillars; there were also the remains of a spider.

The vegetable food of the species seemed to consist mostly of seeds, but they were so broken up as to defy recognition. A little fruit pulp and a little mast were also found. It is difficult to imagine a group of birds that do more good and ask less for the service than the titmice.

### THE ROBIN (Merula migratoria).

The robin (fig. 21) is found throughout the United States east of the Great Plains, and is represented farther west by a slightly different subspecies. It extends far north through Canada, and is found even in Alaska. Although the great bulk of the species leaves the Northern States in winter, a few individuals remain in sheltered swamps, where wild berries furnish abundant food. The food habits of the robin have sometimes caused apprehension to the fruit grower, for it is fond of cherries and other small fruits, particularly the earlier varieties. For this reason many complaints have been lodged against the bird, and some persons have even gone so far as to condemn it. The robin is, however, far too valuable to be exterminated, and choice fruit can be readily protected from its depredations.

An examination of 500 stomachs shows that over 42 per cent of its food is animal matter, principally insects, while the remainder is made up largely of small fruits or berries. Over 19 per cent consists of beetles, about one-third of which are useful ground beetles, taken mostly in spring and fall, when other insects are scarce. Grasshoppers make up about one-tenth of the whole food, but in August comprise over 30 per cent. Caterpillars form about 6 per cent, while the rest of the animal food, about 7 per cent, is made up of various insects, with a few spiders, snails, and angleworms. All the grasshoppers, caterpillars, and bugs, with a large portion of the beetles, are injurious, and it is safe to say that noxious insects comprise more than one-third of the robin's food.

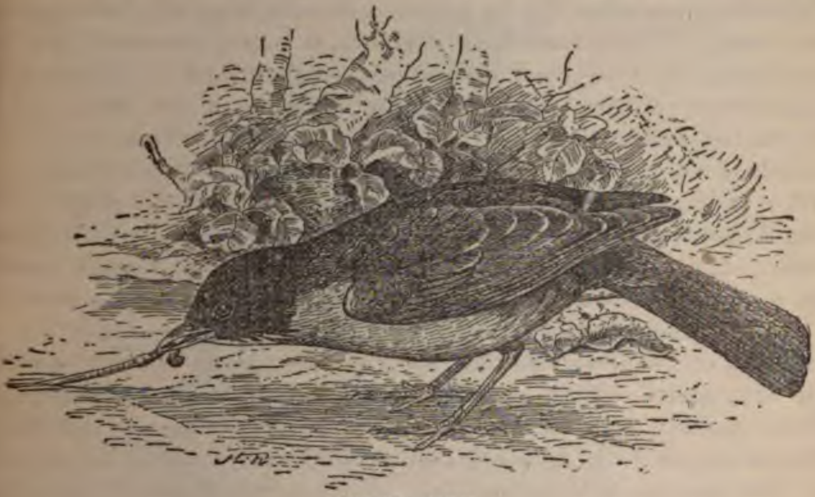

FIG. 21.—Robin.

Vegetable food forms nearly 58 per cent of the stomach contents, over 47 per cent being wild fruits, and only a little more than 4 per cent being possibly cultivated varieties. Cultivated fruit amounting to about 25 per cent was found in the stomachs in June and July, but only a trifle in August. Wild fruit, on the contrary, is eaten in every month, and constitutes during half the year a staple food. No less than 42 species were identified in the stomachs; of these, the most important were 4 species of dogwood, 3 of wild cherries, 3 of wild grapes, 4 of greenbrier, 2 of holly, 2 of elder; and cranberries, huckleberries, blueberries, barberries, service berries, hackberries, and persimmons, together with 4 species of sumac, and various other seeds not strictly fruit.

The depredations of the robin seem to be confined to the smaller and earlier fruits, few, if any, complaints being made against it on the score of eating apples, peaches, pears, grapes, or even late cherries. By the time these are ripe the forests and hedges are teeming with wild fruits, which the bird evidently finds more to its taste. The cherry, unfortunately, ripens so early that it is almost the only fruit accessible at a time when the bird's appetite has been sharpened by a long-continued diet of insects, earthworms, and dried berries, and it is no wonder that at first the rich juicy morsels are greedily eaten.

In view of the fact that the robin takes ten times as much wild as cultivated fruit, it seems unwise to destroy the birds to save so little. Nor is this necessary, for by a little care both birds and fruit may be preserved. Where much fruit is grown, it is no great loss to give up one tree to the birds, and in some cases the crop can be protected by scarecrows. Where wild fruit is not abundant, a few fruit-bearing shrubs and vines judiciously planted will serve for ornament and provide food for the birds. The Russian mulberry is a vigorous grower and a profuse bearer, ripening at the same time as the cherry. So far as observation has gone, most birds seem to prefer its fruit to any other. It is believed that a number of mulberry trees planted around the garden or orchard would fully protect the more valuable fruits.

Many persons have written about the delicate discrimination of birds for choice fruit, asserting that only the finest and costliest varieties are selected. This is contrary to all careful scientific observation. Birds, unlike human beings, seem to prefer fruit like the mulberry, that is sweetly insipid, or one that has some astringent or bitter quality like the chokecherry or holly. The so-called black alder (*Ilex verticillata*), which is a species of holly, has bright scarlet berries, as bitter as quinine, that ripen late in October, and remain on the bushes through November. Though frost grapes, the fruit of the Virginia creeper, and several species of dogwood are abundant at the same time, the birds eat the berries of the holly to a considerable extent, as shown by the seeds found in the stomachs. It is, moreover, a remarkable fact that the wild fruits, upon which the birds feed largely, are those which man neither gathers for his own use nor adopts for cultivation.

### THE BLUEBIRD (Sialia sialis).

The common and familiar bluebird (fig. 22) is an inhabitant of all the States east of the Rocky Mountains from the Gulf of Mexico northward into Canada. It winters as far north as southern Illinois in the Mississippi Valley and Pennsylvania in the east; in spring it is one of the first migrants to arrive in the Northern States, and is always welcomed as an indication of the final breaking up of winter. It freuents orchards and gardens, where it builds its nest in hollow trees, r takes advantage of a nesting box provided by the farmer's boy.

So far as known, the bluebird has not been accused of stealing fruit r of preying upon crops. An examination of 300 stomachs showed hat 76 per cent of the food consists of insects and their allies, while he other 24 per cent is made up of various vegetable substances, found nostly in stomachs taken in winter. Beetles constitute 28 per cent of the vhole food, grasshoppers 22, caterpillars 11, and various insects, ncluding quite a number of spiders, comprise the remainder of the nimal diet. All these are more or less harmful, except a few predaeous beetles, which amount to 8 per cent. In view of the large onsumption of grasshoppers and caterpillars, we can at least condone his offense, if such it may be called. The destruction of grasshoppers is very noticeable in the months of August and September, when these insects form more than 60 per cent of the diet.

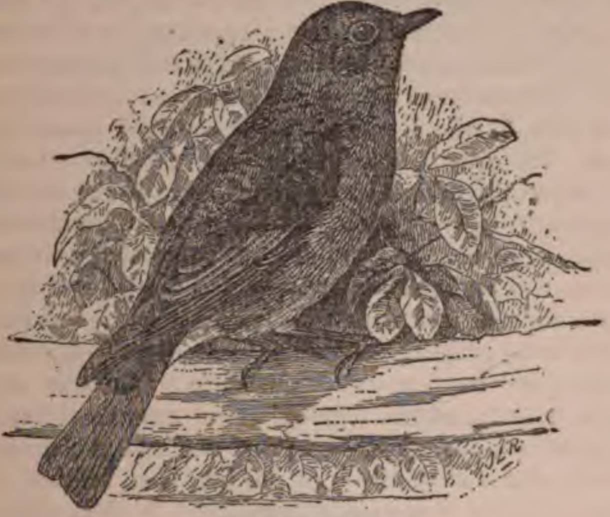

Fig. 22.—Bluebird.

It is evident that in the selection of its food the bluebird is governed more by abundance than by choice. Predaceous beetles are eaten in spring, as they are among the first insects to appear; but in early summer caterpillars form an important part of the diet, and are replaced a little later by grasshoppers. Beetles are eaten at all times, except when grasshoppers are more easily obtained.

So far as its vegetable food is concerned, the bluebird is positively harmless. The only trace of any useful product in the stomachs consisted of a few blackberry seeds, and even these more probably belonged to wild than cultivated varieties. Following is a list of the various seeds which were found: Blackberry, chokeberry, juniperberry, pokeberry, partridgeberry, greenbrier, Virginia creeper, bittersweet, holly, strawberry bush, false spikenard, wild sarsaparilla, sumac (several species), rose haws, sorrel, ragweed, grass, and asparagus. This list shows how little the bluebird depends upon the farm or garden to supply its needs, and indicates that by encouraging the growth of some of these plants, many of which are highly ornamental, the bird may be induced to make his home on the premises.

### THE WESTERN BLUEBIRDS.

Two species of bluebirds inhabit the Western States—the mountain bluebird (*Sialia arctica*) and the Western bluebird (*S. mexicana*-subspecies). In their food habits they are even more to be commended than their eastern relative. Their insect food is obtainable at all times of the year, and the general diet varies only in the fall, when some fruit, principally elderberries, is eaten, though an occasional blackberry or grape is also taken. In an examination of 92 stomachs of *Sialia m. occidentalis* animal matter (insects and spiders) was found to the extent of 76 per cent and vegetable matter to the extent of 24 per cent. The bulk of the former consists of bugs, grasshoppers, and caterpillars. The grasshoppers are eaten freely during the whole season, when they can be obtained. Caterpillars also are a favorite food, and are eaten during every month of the year. Two stomachs, taken in January, contained 64 and 50 per cent, respectively, of caterpillars. Beetles also are eaten and comprise mostly harmful species.

The vegetable matter consists of a few weed seeds and small fruits. In December a few grapes are found, but elderberries are the favorites whenever they can be obtained. It is only when these are in their greatest abundance that the vegetable food exceeds the animal food.

In the systematic arrangement of the birds of America, the bluebird has been placed at the head of the list, i. e., highest in point of development. In its food habits, considered in their economic relations, and in its general behavior toward the human race, the bird occupies a similar position.

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COLLEGE
San Francisco, Cal.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 59.

# EE KEEPING.

BY

FRANK BENTON, M. S.,
IN CHARGE OF APICULTURAL INVESTIGATIONS.

[Revised, March, 1905.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1905.

# LETTER OF TRANSMITTAL.

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U. S. Department of Agriculture,
Bureau of Entomology,
*Washington, D. C., March 24, 1905.*

Sir: Frequent inquiries from correspondents of the Department of riculture for information on matters pertaining to the culture bees, and particularly as to the conditions under which one may sonably expect to meet with success in this pursuit, led to the prep- tion of this bulletin in July, 1897. Though designed by the hor primarily to answer a few of the specific questions which are st likely to present themselves to the mind of the inquirer wholly familiar with the subject, the aim has been also to introduce in the atment of the various topics information which it is hoped will d many of longer experience into more successful methods than y have yet practiced. The stereotype plates of the earlier editions ving become much worn, necessitating the resetting of the type the entire bulletin, the opportunity has been afforded of inserting eral new paragraphs and making a few slight changes in the text heretofore published.

Respectfully,

L. O. Howard,
*Entomologist.*

Hon. James Wilson,
*Secretary of Agriculture.*

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# BEE KEEPING.

## LOCATIONS SUITED TO THE KEEPING OF BEES.

It may be safely said that any place where farming, gardening, or fruit raising can be successfully followed is adapted to the profitable keeping of bees—in a limited way at least, if not extensively. Many of these localities will support extensive apiaries. In addition to this there are, within the borders of the United States, thousands of good locations for the apiarist—forest, prairie, swamp, and mountain regions—where agriculture has as yet not gained a foothold, either because of remoteness from markets or the uninviting character of soil or climate. This pursuit may also be followed in or near towns and, to a limited extent, in large cities. It even happens in some instances that bees in cities or towns find more abundant pasturage than in country locations which are considered fair.

The city of Washington is an example of this, bees located here doing better during the spring and summer months than those in the surrounding country, owing to the bee pasturage found in the numerous gardens and parks and the nectar-yielding shade trees along the streets. This is due mainly to the fact that the linden, or basswood, which is rarely seen in the country about Washington, has been planted extensively in the parks and for miles on both sides of many of the streets and avenues of the city.[a] Another source in the city not found extensively in the country adjacent is melilot, Bokhara or sweet clover (*Melilotus alba*), which has crept into vacant lots and neglected corners, and diffuses its agreeable perfume to the delight of all city dwellers, whether human or insect. The writer has practiced with profit the transportation of nearly a hundred colonies from a country apiary 10 miles distant to Washington for the linden and sweet clover yield. He has also seen a prosperous apiary kept on the roof of a business house in the heart of New York City, and on several occasions has visited another apiary of 30 to 40 colonies, which a skillful apiarist had located on the roof of his store in the business portion of Cincinnati, Ohio, and from which 30 to 40 pounds of honey per colony were usually obtained each year.

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[a] Several species of lindens are included in these plantings, but none yields more than our common American linden, or basswood (*Tilia america*

Another apiary personally inspected was located directly on the sand banks forming the eastern shore of Lake Michigan. These bees were, of course, unable to forage westward from the apiary, hence had but half "a field." The soil of the area over which the bees ranged was a light sand, unproductive for most crops, and the region was little developed agriculturally, most of the honey coming from forest trees and from shrubs and wild plants growing in old burnings and windfalls, yet 25 to 30 pounds of excellent honey per colony was the usual surplus obtained. At one time the writer had an apiary in the city of Detroit, Mich., where the wide river on one side cut off nearly half of the pasturage, yet the bees did will. And again for several years he had an apiary containing from 100 to 200 colonies of bees on a very sterile coast of the Island of Cyprus, and another nearly as large located but a few rods from the seashore on a rocky point of Syria. Both of these apiaries were devoted in the main to queen rearing, yet the yield of honey was not an unimportant item, especially in the Syrian apiary, while in the Cyprus apiary some honey was frequently taken, and it was rarely necessary to feed the bees for stores. In the latter case about one-fourth of the range was cut off by the sea, the bees being located at the head of an open bay and a short distance from the shore, while the location of the Syrian apiary prevented the bees from securing half of the usual range, hence their greater prosperity was due to the nature and quantity of the pasturage of their limited range.

It is evident, therefore, that no one similarly located need be deterred from keeping bees, provided the nectar-yielding trees and plants of the half range are of the right sort and abundant. Moreover, regions so rough and sterile or so swampy as to give no encouragement to the agriculturist, or even to the stock raiser, will often yield a good income to the bee keeper, insignificant and apparently worthless herbs and shrubs furnishing forage for the bees. The ability of the bees to range over areas inaccessible to other farm stock and to draw their sustenance from dense forests when the timber is of the right kind, and the freedom which, because of their nature, must be accorded them to pasture on whatever natural sources are within their range of 3 or 4 miles, must be taken into account in estimating the possibilities of a locality. It will be found that very few localities exist in our country where at least a few colonies of bees may not be kept. Whether a large number might be profitably kept in a given locality can be decided only by a careful examination as to the honey-producing flora within range of the apiary (see pp. 12 and 26–29).

The danger of overstocking a given locality is very frequently exaggerated. Each range, it is self-evident, has a limit. The writer is, however, fully convinced, after long experience in numerous localities and under the most varied circumstances, that three or four times as many colonies as are commonly considered sufficient to stock a given range may usually be kept with a relative degree of profit. But to secure such results sufficient care and close observation have too frequently not been given in the selection of bees adapted to the locality and conditions. A more frequent failure has been lack of proper attention to the individual colonies, particularly as to the age and character of the queens in each. The space given for brood rearing is often too small, and frequently no care is given to secure the proper amount of brood in time to insure a population ready for each harvest. Attention to these points would enable great numbers of bee keepers who now regard 50 to 100 colonies as fully stocking their range to reach several hundreds in a single apiary, with slight or no diminution in the average yield per colony.

## THE RETURNS TO BE EXPECTED FROM AN APIARY.

Although apiculture is extremely fascinating to most people who have a taste for the study of nature, requiring, as it does, out-of-door life, with enough exercise to be of benefit to one whose main occupation is sedentary, the income to be derived from it when rightly followed is a consideration which generally has some weight and is often the chief factor in leading one to undertake the care of bees. Certainly, where large apiaries are planned, the prime object is the material profit, for they require much hard labor and great watchfulness, and the performance of the work at stated times is imperative, so that in this case there is less opportunity than where but a few colonies are kept to make a leisurely study of the natural history and habits of these interesting insects, because—unless the keeper is willing to forego a considerable portion of his profits—his time must necessarily be almost wholly taken up in attending to the most apparent wants of his charges.

One very naturally supposes that the return from a single hive, or several of them, in a given locality, may be taken as a fair index of what may be expected each season. Such return, if considered average, may serve as a basis on which to reckon, but as so many conditions influence it, great differences in actual results will be found to occur in successive seasons. Apiculture, like all other branches of agriculture, depends largely upon the natural resources of the location, and the favorableness or unfavorableness of any particular season, no matter how skillful the management, may make great differences in the year's return. The knowledge, skill, industry, and promptness of the one who undertakes the care of the apiary have likewise much to do with the return. Furthermore, profits are of course largely affected by the nature and proximity of the markets.

A moderate estimate for a fairly good locality would be 35 to 40 pounds of extracted honey or 25 pounds of c [illegible] y.

This presupposes good wintering and an average season. When two or more of the important honey-yielding plants are present in abundance and are fairly supplemented by minor miscellaneous honey plants the locality may be considered excellent, and an expectation of realizing more than the yield mentioned above may be entertained. With extracted honey of good quality at its present wholesale price of 6 to 8 cents per pound and comb honey at 12 to 14 cents, each hive should under favorable circumstances give a gross annual return of $2.50 to $3. From this about one-third is to be deducted to cover expenses other than the item of labor. These will include the purchase of comb foundation and sections, repairs, eventual replacing of hives and implements, and the interest on the capital invested. By locating in some section particularly favorable to apiculture—that is, near large linden forests, with clover fields within range, supplemented by buckwheat; or in a section where alfalfa is raised for seed; where mesquite, California sages, and wild buckwheat abound; where mangrove, palmettoes, and titi, or where sourwood, tuliptree, and asters are plentiful—the net profits here indicated may frequently be doubled or trebled.

But these favored locations, like all others, are also subject to reverses—the result of droughts, great wet, freezes which kill back the bee pasturage, etc., and though some years the profits are so much larger than those named above as to lend a very roseate hue to the outlook for the accumulation of wealth on the part of anyone who can possess himself of a hundred or two colonies of bees, the beginner will do well to proceed cautiously, bearing in mind that much experience is necessary to enable him to turn to the best account seasons below the average, while during poor seasons it will take considerable understanding of the subject, energetic action, and some sacrifice to tide over, without disaster, or at least without such great discouragement as to cause neglect and loss of faith in the business. On the whole, there should be expected from the raising of bees for any purpose whatever only fair pay for one's time, good interest on the money invested, and a sufficient margin to cover contingencies. With no greater expectations from it than this, and where intelligence directs the work, apiculture will be found, in the long run, to rank among the best and safest of rural industries.

The value of bees in the pollination of various fruit and seed crops is often sufficient reason to warrant the keeping of a small apiary, even if circumstances do not favor its management in such a manner as to secure the largest possible crops of honey or to insure the saving of all swarms. The quality and quantity of many varieties of apples, pears, plums, and small fruits depend absolutely upon complete cross-pollination. The most active agents in this work are honey bees.

## YONE WHO DESIRES TO DO SO CAN LEARN TO MANIPULATE BEES.

Any person with fairly steady nerves and some patience and courage easily learn to control and manipulate bees. There are, it is true, ew exceptional individuals whose systems are particularly suscepti- to the poison injected by the bee, so much so that serious effects ow a single sting. Such cases are, however, very rare. In most tances where care is not taken to avoid all stings the system even- lly becomes accustomed to the poison, so that beyond momentary n a sting causes no inconvenience.

o a certain extent the belief exists that bees have, without apparent se, a violent dislike for some people, while others, without any effort, received into their favor. The latter part of this proposition has etter foundation than the first part, for it is the actions, rather than y peculiarity of the individual himself, that anger the bees.

Bees prefer, of course, not to be disturbed; hence they usually keep ards on the lookout for intruders. When visitors approach the hives ese guards are very apt to fly toward them as if to inquire whether rm is intended or not, and should the visitor not inspire them with r by using smoke or some similar means, but should himself show r and nervousness, he will be very likely to arouse their suspicions ll further, or even to anger them should he strike at them or endeavor dodge their approach. Indeed, one not accustomed to the notes of es is very likely, unconsciously, to dodge his head about when a rker buzzes uncomfortably close to his face. It may be a movement but an inch or two, but perhaps a quick jerk, and being noticed by suspicious guard is resented; a sting follows, and yet the recipient lares that he did nothing to cause the attack, but that bees merely e him and always sting him when he approaches them. On the er hand, an equally unprotected person who moves about with iberation may generally, under the same circumstances, be let off thout receiving a sting. It is in this case not so much what he does what he does not do.

It is not to be understood that bees will always refrain from stinging one remains somewhat passive in the vicinity of their hives, for the ct is that at some seasons common black bees and crosses having ood of this race fly some distance to attack passers-by, or even, with- t just provocation and with but slight warning, to plant a sting in e face of one who is standing near the apiary. But as the avoidance such unpleasant occurrences depends largely upon the kind of bees pt, and, to a certain extent, upon an acquaintance with a few facts th which anyone of intelligence may easily familiarize himself, and e observance of certain precautions which are quite simple and after a little practice will become easy, and as the opening and manipulation of hives in securing honey, etc., is equally simple and attended with no greater risks, it is safe to say that almost anyone can, with perseverance and the exercise of due caution, learn to manipulate bees with perfect freedom and without serious risk of being stung.

## HOW TO AVOID STINGS.

Stings can be avoided, first, by having gentle bees. If no other point of superiority over the common brown or black bee than that of gentleness could be fairly claimed for some of the races introduced and some of the strains developed in recent years, it would still be worth while to get them on this account alone. When the fact of superiority in several other important points is considered also, there should be no further question as to the advisability of procuring them in preference to the common variety. The beginner is advised never to think of doing otherwise. No one likes stings, and even the veteran who affects insensibility to the wrath of his charges will find his interest and pleasure in them much increased by replacing blacks and their crosses with better varieties. Nor is this merely to gratify a fancy or for convenience alone. If, by reason of the stinging qualities of the bees kept, an examination for the purpose of ascertaining the condition of a colony of bees becomes a disagreeable task to the one who cares for the apiary, little things necessary to the welfare of the colonies will be postponed or omitted altogether and the apiary will soon present a neglected appearance, and the actual profits will be affected.

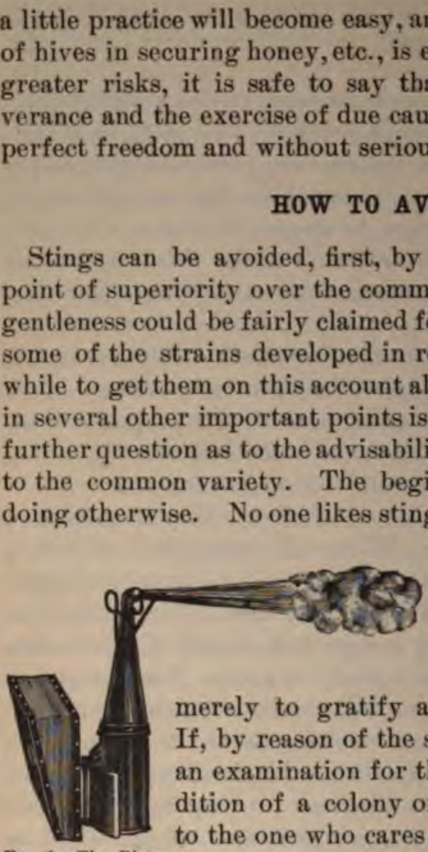

FIG. 1.—The Bingham bee smoker.

Of the races already in general cultivation, Carniolans are the gentlest, although Caucasians, more recently introduced from southeastern Russia and only now being put on sale, are by far the least inclined to sting of any bees, and may be handled at all times without resorting to the protection of a bee veil, and generally without smoke, or at most a very slight application of smoke. Some strains of Italians equal in gentleness average Carniolans, but in general the race native to Italy is by no means as gentle as that found in Carniola, Austria, and the Caucasians are much to be preferred for the beginner. In case these gentler races are not easily procurable he need not hesitate, however, to undertake, after adopting due precautions, the manipulation of pure Italians.

In crossing well-established breeds the males of a gentle race should be used, otherwise the workers of the cross may vary greatly in temper, especially in the first few generations. Only careful selection continued for some time will so fix the desirable traits as to result in their reproduction with a fair degree of certainty in the offspring. Bees having the blood of blacks and Italians are nearly always quite vicious in the case of the first cross, and are even harder to subdue with smoke than are pure blacks. Other races need not be considered here, as they are adapted to special purposes; and the skill of the bee-master, the conditions of climate, flora, etc., and the particular line of production to be followed, should decide whether their introduction is advisable or not.[a]

The second essential to enable one to avoid stings is to have a good smoker at hand whenever the bees are to be handled. Any way of getting smoke of any kind into the hive and about it may answer the purpose, but for ease and effectiveness in keeping bees under control nothing will take the place of the modern bellows smoker (fig. 1). A good one lasts years, and its cost is so slight ($1 to $1.25 for the medium sizes) that the expenditure may be considered one of the wisest that can be made in fitting up an apiary.

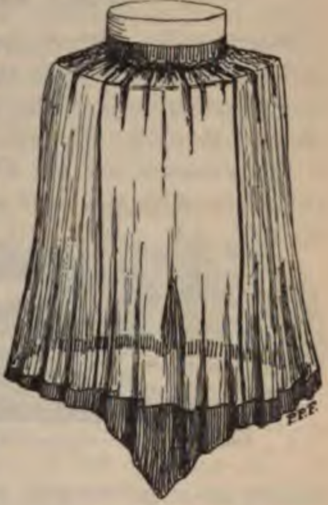
FIG. 2.—Bee veil.

A veil (fig. 2), made of black bobinet or Brussels net, to draw over the hat, and a pair of gloves, preferably of rubber, may be used at first. But whoever has fairly peaceable bees and learns even a little about their ways will soon discard the gloves, unless, indeed, he be exceedingly timid, or one of those to whom a bee sting would be a dreadful affliction. The veil can be safely dispensed with if the gentlest bees are kept.

Simple and convenient hives, employing the Langstroth principle, and with stories and frames interchangeable and so constructed as to reduce propolization to a minimum and to insure straight combs, will much facilitate the avoidance of stings.

The use of the bee escape (fig. 3) in removing surplus honey greatly reduces the risk of being stung during this operation, for it saves much manipulation of combs and shaking and brushing of bees. This useful device is fitted into a slot made in a board the same size as the top of the hive, and the whole, when slipped in between the brood apartment and an upper story or super, will permit all of the workers above to go down into the lower story but not to return to the top above to go down into the lower story, but not to return to the top one, so that in one night it is possible to free entirely a set of combs from bees without any manipulation of the combs, and without smoking, shaking, or brushing the bees.

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[a] For a fuller discussion of this subject, see "The Honey Bee: A Manual of Instruction in Apiculture," by Frank Benton, M. S., Bulletin No. 1, new series, Bureau of Entomology, U. S. Dept. of Agriculture, third edition, 1899, Chap. I.

Lastly, reasonable care in manipulation and a suitable system of management, which, of course, implies the doing of work in proper season, will, with the observance of the foregoing points, make the risk of stings exceedingly slight. Indeed, intelligent attention to the most important of the points mentioned above, with extra gentleness and moderation in manipulation, will enable anyone who so desires to avoid all stings.

## WHAT RACE OF BEES TO CHOOSE.

Reference has already been made to the relative gentleness of the various races, and since the gentler types are themselves excellent honey gatherers, and the particular advantages to be derived from some of the more energetic races which do not happen to be so mild in temperament are not likely to be secured by the beginner who is unfamiliar with the most approved methods of manipulation of such bees, it is strongly recommended that only the gentle ones be at first adopted—either Caucasians, Carniolans, or Italians. Should full colonies of these not be obtainable near home, colonies of ordinary bees may be changed by replacing their queens with queens of the desired race, the latter having been procured in small boxes by mail. If possible the introduction had better be made by an expert, although in general, by following the instructions which accompany the new queen, success will also be attained by the beginner.

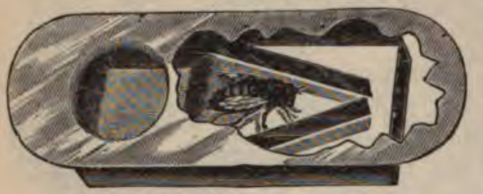


FIG. 3.—The Porter spring bee escape.

A brief summary of the leading traits of the various races now in this country will be of use in guiding the purchaser, as well as instructive to him for reference.

**Caucasians** are natives of that portion of Russia lying between the Black and Caspian seas, are exceedingly gentle, good workers, good defenders of their hives, prolific, build many queen cells, and swarm often if confined to small hives. The workers are dark leaden gray in their general color, and present quite a ringed appearance because of the alternation of this dark color with the lighter fuzz which edges the segments of the abdomen. They also show frequently one to two yellow or leather-colored bands, are somewhat smaller bodied than Italians or Carniolans, have good wing-expanse, and hence are nimble flyers. The drones are rather small and quite dark in color; queens not large, and vary in color from a coppery-yellow to a dark bronze.

**arniolans** are much larger bodied and somewhat lighter gray in
r than the Caucasians, but show likewise in many instances one or
rusty or dark-red bands. Their great hardiness and excellent
g power enable them to fly freely in much cooler weather than
e other races stand, and to regain their hive entrances under adverse
litions. They are prolific, active, and good honey gatherers, pro-
ing combs of snowy whiteness. As in the case of the Caucasians,
r prolificness causes them to fill small hives to overflowing with bees,
this naturally results in numerous swarms. It is therefore advis-
to use hives containing ten to twelve frames in the brood chamber.
nature of the Carniolans is essentially a quiet one, so that upon
approach of cold weather they settle down in a very compact and
emely quiet cluster, a condition which contributes in no small
ree to their excellent wintering qualities. The drones are the
est of all drones of this species, and are covered with a thick coat
ray fuzz. The queens vary from a light color to a very dark
her color, the typical queen being, however, dark bronze, large,
rounded, strong, and active.

**alians**, the first of the foreign races to be introduced into this
ntry, are much more widely known, and have with reason found
at favor, since they are industrious, good defenders of their hives,
excellent honey gatherers, as well as handsome in appearance,
g usually evenly marked with three yellow bands across the
rior portion of the abdomen. The blood has become so dissemi-
d through the apiaries of the country that many hybrid bees
ing but one to two yellow bands are counted as Italians, and their
s disposition, derived through the males of the common race, is
ged to the Italians. Strains of Italians pure in blood have been
l by selection in this country until the three yellow bands have
me so wide as to be nearly or quite joined, and in some instances
ly the whole abdomen is yellow. In general, however, as regards
ering powers it does not seem that any improvement has been
e by this selection, the dark or leather-colored Italians proving,
n all, more vigorous, gentle, and better honey gatherers, while as
rds wintering they are also superior. It must be acknowledged,
ever, that the Italian race is slightly inferior in wintering qualities
ll of the others which have been generally introduced into America.

**yprians**, from the island of Cyprus, may be taken as a general type
which to compare other eastern races. They are small bodied,
e slender, in fact, than any of the European races of bees. The
men is more pointed and shows, when the bees are purely bred,
e light-colored bands on the upper surface, and considerable yel
on the under side. Between the wing attachments on the thorax

is a little prominence, shaped like a half moon, which is usually quite plainly yellow in color. The queens are small bodied, yellow in color, with more or less black at the tip of the abdomen. The drones have a heavy coat of fuzz on the thorax, and the abdomen presents a mottled yellow appearance, being often highly yellow. Cyprians possess longer tongues and greater wing-power than other races. This, combined with great prolificness and most remarkable activity, renders them the best of honey gatherers. In temper, however, they may be regarded as rather aggressive, rendering their management by any who are not experts extremely difficult. This feature may, however, be largely overcome by crossing the queens of this race with the drones of very gentle types. In this manner bees are produced that are readily amenable to smoke and ordinary methods in manipulation, combined with the excellent honey-gathering powers and prolificness of the eastern races.

**Cyprio-Carniolans and Cyprio-Caucasians.**—The author conceived the idea in the early eighties that by crossing the Cyprian and Carniolan races a type might be developed which would combine the excellent traits of both of these. The first matings of Cyprians and Carniolans were made by him in 1883 in Carniola itself, thus insuring positively the fecundation of the Cyprian queens by Carniolan drones. Bees combining the blood of the two races in various proportions have since been tested for years in comparison with all other known races, with the result that the cross mentioned above has been found to exceed all of the pure races in honey-gathering powers, owing undoubtedly to the combination of great energy, hardiness, prolificness, and wing-power, as well as greater length of tongue—a fact established by actual measurements. Similar results, with even greater gentleness, may be expected from the cross obtained between Cyprian queens and Caucasian drones.

**Syrian and Palestine or "Holy-Land" bees.**—What has been said of Cyprians may be taken to apply in a general sense to Syrian and Palestine bees, except that in these the good qualities are slightly less prominent, while some of the bad ones of the Cyprians are accentuated. No separate description of these is, therefore, particularly necessary in this place.

**German, Common Black, or Brown bees.**—The bees commonly found wild, and cultivated to a greater or less extent, in this country, and known under the above name, are probably derived from early introductions from the Old World. In comparison with the races above enumerated, they may be said to be inferior, since they possess the least energy in honey collecting, are less prolific, and not as good defenders of their hives. Under favorable conditions, however, as regards pasturage they may be relied upon for excellent results. They

however, spiteful under manipulation, and have the disagreeable
of running from the combs and dropping in bunches on the
nd, likewise of flying from the hive entrance and attacking pass-
y. They are more easily discouraged than other bees during
times as regards honey production, and this is doubtless the main
n for their generally inferior economic value.

## WHAT HIVE TO ADOPT.

e suspended Langstroth frame is used more than any other frame
g English-speaking bee keepers. It is safe to say that in the
ed States 500 hives are made and used which are essentially Lang-
h in principle to one frame hive of any other kind whatever. In
British Islands, Australia, and New Zealand the proportion of
es on the Langstroth principle
se is probably even greater,
ely any other frame hives be-
mployed.

success of American bee culture in
st twenty years was first attributed by
ean bee keepers to the honey-pro-
g power of the country; but the most
gent apiarists who have tried the
ican methods with the Langstroth
now recognize that success is princi-
due to the manipulations that it
ts. ("The Hive and Honey Bee,"
d, 1888, page 145.)

can predict, and without any fear of
ke, that the principles on which the
troth hive is based will be admitted
r or later by the most progressive bee
rs of the world. ("Revue Interna-
e d'Apiculture" (Switzerland), Sep-
r, 1885, edited by Edouard Bertrand.)

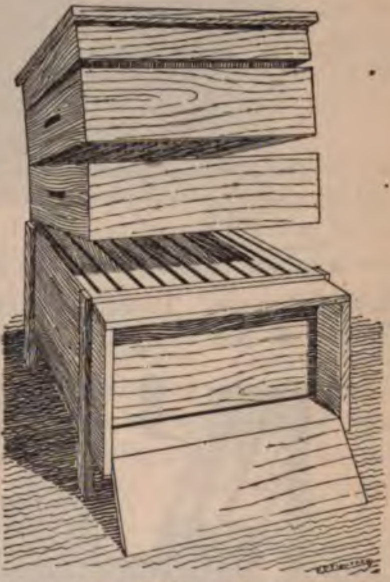


FIG. 4.—Langstroth hive with two half-depth supers for surplus honey.

ere being no patent on the Lang-
h hive, and accurately made
being obtainable at moderate prices from hive factories in various
of the country, it is taken for granted that the enterprising begin-
will adopt a simple form embodying this principle—the loose-
g, suspended comb frame—as its main feature. The hive should
nly be substantially built, but should have accurate bee-spaces and
e-fitting, rain-proof cover or roof. Factory-made hives, as a rule,
meet these requirements, as both lock joints and halved corners can
be made to advantage by machinery, and the expert hive builder
rstands, of course, the absolute necessity of great accuracy in bee-
s, as well as the great desirability of good material and work-

manship (figs. 4, 5, and 11). Provision should also be made for winter protection. (See pages 39–41.)

For comb honey, hives permitting the insertion in the brood apartment of any number of frames up to eight, or frequently up to ten, are most in use. In securing extracted honey, those with ten to twelve frames in each story are preferable, and as many stories, one above the other, are employed as the strength of the colony and a given harvest may require. A construction, therefore, which readily admits of expansion and of contraction, as occasion demands, is desirable.

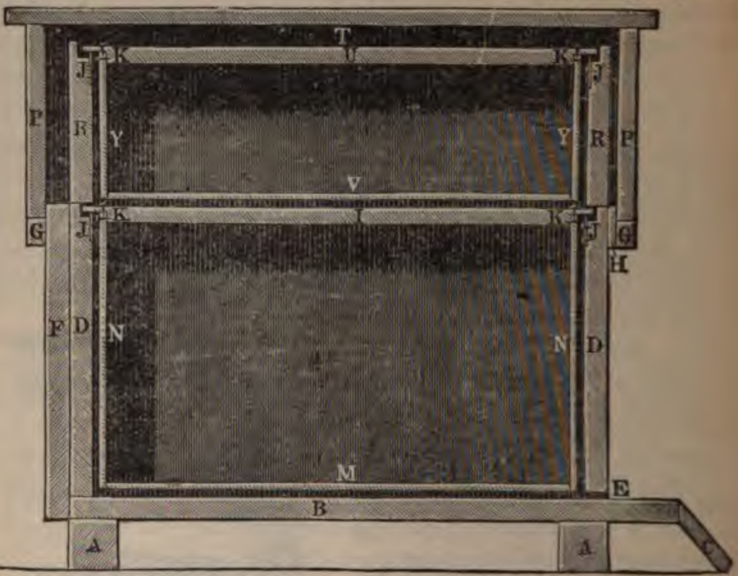


FIG. 5.—The Langstroth hive—Dadant-Quinby form—cross section showing construction.

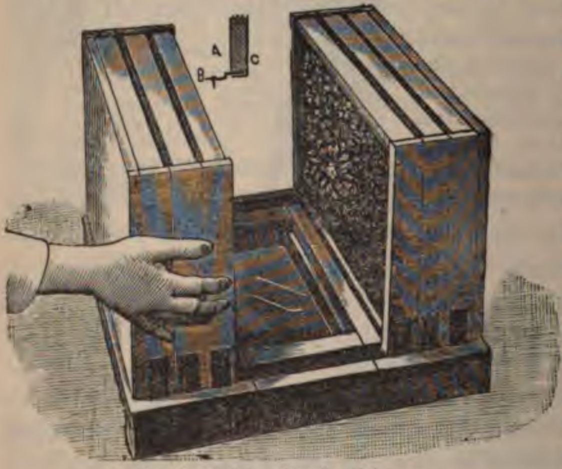


FIG. 6.—Quinby closed-end frames.

Mention should be made of a hive of quite different construction, a prominent feature of which is this ease of contraction and expansion. It is the last hive which the late M. Quinby gave to the public—the Quinby closed-end frame hive (fig. 6). This hive is used with great success by certain American bee keepers of long experience and whose apiaries are among the largest in the world.

## MANAGEMENT IN SWARMING.

### NATURAL SWARMING.

When a swarm is seen issuing or in the air, the best thing to do is, in general, simply to wait a bit. The weather is usually rather warm then, and rushing about to get tin pans, dinner gongs, spraying outfits, etc., aside from its disagreeableness, may get one so excited and into such a perspiration as to unfit him to do with the bees that which is likely to be necessary a few minutes later. The bees will probably gather in a clump on a tree or bush near the apiary, and however formidable getting them into the hive may at first seem, nothing will be simpler than shaking them into their new hive, or into a basket or box, from which they may be poured in front of the hive, just as one would pour out a measure of wheat or beans. If any stick to the basket or box, invert it and give a sharp thump with one edge against the ground. If the hive has been standing in the shade so that the boards composing it are not heated, and if it be now well shaded and plenty of ventilation be given above and below, the bees are almost certain to take possession at once and begin work actively.

The securing of swarms can be made, however, even simpler than this by having the colonies placed several feet apart on a smooth lawn or dooryard and clipping one wing of each laying queen so as to prevent her flying. The prime or first swarm from each hive is accompanied by the old queen, and if she be clipped she will of course fall from the alighting board to the ground and may be secured in a cage. The bees will circle about a few times and return. Meanwhile the only thing for the attendant to do is to replace the parent colony by an empty hive. The returning bees will enter the latter and the queen may be allowed to go in with them, the cage being placed with its open end directly against the entrance to insure this. The swarm is thus made to hive itself.

The parent colony removed to a new stand a rod or more away will rarely give a second swarm. But to make certain all queen cells except one may be cut out four or five days after the issuance of the first swarm. At the same time one-third to one-half of the remaining bees of the removed colony may be shaken at the entrance of the hive containing the swarm. This reduces the population of the parent colony greatly, but the loss is soon made good by the young workers emerging daily, and the new queen which will issue from the single queen-cell, spared when cutting out cells, will soon restock the hive with brood. The shaking out of additional bees, coupled with the removal of all queen cells but one, will prevent for the time all further swarming from the given hive, and in most instances end it for the season. The bees thus added to the newly hived swarm, even though too young to enter the field at once as honey gatherers. will nevertheless release from inside work an equal number of older bees, enabling the latter to go out as field bees.

Each after-swarm (second, third, etc.), it should be borne in mind, is accompanied by one or more unimpregnated queens, and these must not be clipped until they have flown out and mated. The regular deposition of eggs in worker cells may nearly always be regarded as a safe sign that mating has taken place. Eggs will usually be found in such cells within the first ten days of the queen's life. After-swarms may remain in the air, circling about for some time, and they frequently cluster high—a good reason, in addition to the more important fact that their issuance is not consistent with the production of the most surplus honey, for the prevention of all after-swarming.

## ARTIFICIAL SWARMING.

Where an increase of colonies is desired, and in case no one can be near the apiary to care for natural swarms with clipped queens, some one of the artificial methods of forming new colonies may be advantageously employed. Natural swarming is, however, to be preferred to a poor system of artificial increase. And no matter which of the artificial methods be adopted, it should be cautiously followed, lest, should unfavorable weather appear suddenly, considerable labor and expense be incurred to prevent disastrous results. It is also of prime importance not to weaken materially the gathering powers of strong colonies just at the opening of the harvest or during its progress; hence, whatever division takes place then must leave the field force—the gatherers—in one mass and in normal condition for work, that is, not discouraged by being queenless, and not overburdened by having brood without a sufficient number of nurse bees to care for it.

**Dividing.**—A plan which fulfills these conditions is the following: From a populous colony a comb or two with adhering bees and the queen may be taken and placed in a new hive, which, when other frames with starters have been added, is then to be put on the stand of the populous colony from which the combs were taken. The removed colony is to be taken a rod or more from its old stand, so that the flight bees returning from the field will enter the newly established colony. The old colony may be given a laying queen or a mature queen cell a day or two later This finishes the work in a short time.

**Nucleus system.**—A better plan, though not so quickly completed, is to take from the populous colony only enough bees and combs to make a fair nucleus on a new stand. A queen is easily and safely introduced into this nucleus, or a queen cell is readily accepted a day or two later. As soon as the young queen has begun egg laying, combs of emerging brood may be added from time to time. These may be obtained from any populous colonies whose tendency to *swarm it* is desirable to check, the bees adhering to them when they are removed being in all instances brushed back into their own hive. With fair pasturage the nucleus will soon be able to build combs and may be given frames of comb foundation, or, if the queen be of the current year's raising, frames with narrow strips of foundation as guides may be inserted, since all combs constructed by the nucleus will be composed of worker cells.

**Shaken or brushed swarms.**—The practice of shaking or brushing bees from the combs of populous colonies into new hives to form artificial or forced swarms has been practiced for many years, to a limited extent in this country and more largely abroad. As early, at least, as 1872 the late C. J. H. Gravenhorst, the editor of Die Illustrierte Bienenzeitung, author of Der Praktische Imker, and inventor of the Bogenstuelper hive, made artificial swarms in this manner. His articles led the author to experiment in this line and finally to settle upon the plan of placing colonies designed for honey production in pairs in the apiary and, after having brought them up to a suitable strength, shaking or brushing most of the bees of the two into a third hive at the approach of the main honey flow, one queen being allowed to enter the new hive with the shaken swarm. The latter is to be placed on the old stand midway in position between the spots previously occupied by the parent colonies, these having been removed some distance, to be managed thereafter as colonies that have swarmed. The newly shaken swarm is to receive comb-foundation starters in the frames and within a day or two surplus receptacles for honey. In case, however, drawn combs be used in the super, there had better be one or two frames in the brood apartment partly filled with completed comb to hold the first pollen collected. The shaking or brushing should be done toward the latter part of the day and during a time when new honey is coming in, or in the absence of the latter liberal feeding should precede the shaking and be kept up until the start of the honey flow. The shaken swarm is thus brought into quite the same condition as usually obtains in the case of a natural swarm. It is able to send out a strong gathering force at once and will store honey rapidly. The increase of 50 per cent is as large as is consistent with the securing of the best honey yield.

## PREVENTION OF SWARMING.

Under the conditions most frequently occurring, however—that is, where it is not practicable to be present at all times during the swarming season, or where the desired number of colonies has been attained—a system of management is advisable which in general contemplates the prevention, in so far as possible, of the issuance of swarms without at the same time interfering with honey storing. The paragraphs following on this subject are taken from the Department publication "The Honey Bee," cited on page 15, footnote:

The most commonly practiced and easily applied preventive measure is that of giving abundant room for storage of honey. This to be effective should be given early in the season, before the bees get fairly into the swarming notion, and the honey should be removed frequently, unless additional empty combs can be given in the case of colonies managed for extracted honey, while those storing in sections should be given additional supers before those already on are completed. With colonies run for comb honey it is not so easy to keep down swarming as in those run for extracted honey and kept supplied with empty comb. Free ventilation and shading of the hives as soon as warm days come will also tend toward prevention. Opening the hives once or twice weekly and destroying all queen cells that have been commenced will check swarming for a time in many instances, and is a plan which seems very thorough and the most plausible of any to beginners. But sometimes swarms issue without waiting to form cells; it is also very difficult to find all cells without shaking the bees from each comb in succession, an operation which, besides consuming much time, is very laborious when supers have to be removed, and greatly disturbs the labors of the bees. If but one cell is overlooked the colony will still swarm. The plan therefore leaves at best much to be desired, and is in general not worth the effort it costs and can not be depended on.

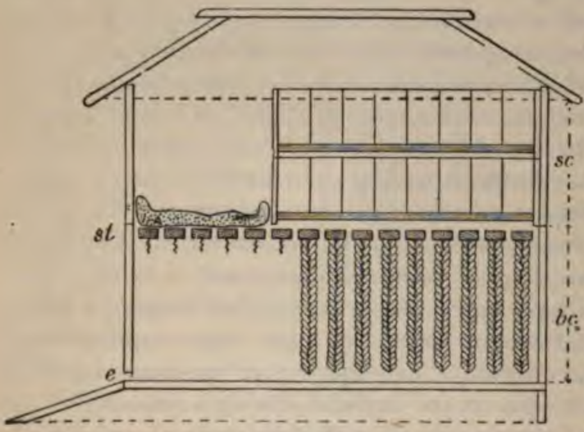


FIG. 7.—The Simmins nonswarming system—single-story hive with supers: *bc*, brood chamber; *sc*, supers; *st*, starters of foundation; *e*, entrance.

**Dequeening.**—The removal of a queen at the opening of a swarming season interferes, of course, with the plans of the bees, and they will then delay swarming until they get a young queen. Then, if the bee keeper destroys all queen cells before the tenth day, swarming will again be checked. But to prevent swarming by keeping colonies queenless longer than a few days at most is to attain a certain desired result at a disproportionate cost, for the bees will not store diligently when first made queenless, and the whole yield of honey, especially if the flow is extended over some time, or other yields come later in the season, is likely or even nearly sure to be less from such colonies, while the interruption to brood rearing may decimate the colony and prove very disastrous to it. The plan is therefore not to be commended.

**Requeening.**—Quite the opposite of this, and more efficacious in the prevention of swarming, is the practice of replacing the old queen early in the season with a young one of the same season's raising, produced, perhaps, in the South before it is possible to rear queens in the North. Such queens are not likely to swarm during the first season, and, as they are vigorous layers, the hive will be well populated at all times and thus ready for any harvest. This is important, inasmuch as a flow of honey may come unexpectedly from some plant ordinarily not counted upon; and also, since the conditions essential to the development of the various honey-yielding plants differ greatly, their time and succession of honey yield will also differ with the season the same as the quantity may vary. Young queens are also safest to head the colonies for the winter. The plan is conducive to the highest prosperity ie colonies, and is consistent with the securing of the largest average yield of y, since, besides giving them vigorous layers, it generally keeps the population her in powerful colonies. It is therefore to be commended on all accounts as in line with the most progressive management, without at the same time fering with the application of other preventive measures.

**ice near entrances.**—Arranging frames with starters, or combs merely begun, een the brood nest and the flight hole of the hive, while the bees are given ng space above or back of the brood nest (figs. 7 and 8), is a plan strongly recended by Mr. Samuel Simmins, of England, and which has come to be known the Simmins nonswarming method," some features of it and the combination a well-defined method having been original with him. It is an excellent preve measure, though not invariably successful, even when the distinctive features ght forward prominently by Mr. Simmins—empty space between the brood s and entrance, together with the employment of drawn combs in the supers—upplemented by other measures dy mentioned; but when, in ion to the space between the d and the flight hole, the precaue taken to get supers on in time, entilate the hive well, and to queens not over two years old, ming will be very limited. If to precautions be added that of ituting for the old queens young of the current season's raising, e swarming has begun, practical unity from swarming is generally ed.

**ection in breeding.**—Some races es show greater inclination than rs toward swarming, and the same rence can be noted between indial colonies of a given race; therewhatever methods be adopted to ent or limit increase, no doubt onstant selection of those queens reed from whose workers show least tendency toward swarming d in time greatly reduce this disposition. Indeed, it is perfectly consistent to ve that persistent effort, coupled with rigid and intelligent selection, will eventresult in a strain of bees quite as much entitled to be termed nonswarming rtain breeds of fowls which have been produced by artificial selection are to be d nonsitters. These terms are of course only relative, being merely indicative of possession of a certain disposition in a less degree than that shown by others of ame species. It might never be possible to change the nature of our honeybees mpletely that they would never swarm under any circumstances, and even if ble it would take a long period, so strongly implanted seems this instinct. But odify it is within the reach of any intelligent breeder who will persistently make ffort. Such work should be undertaken in experimental apiaries where its connce when a single point has been gained will not be affected by the changes of idual fortunes.

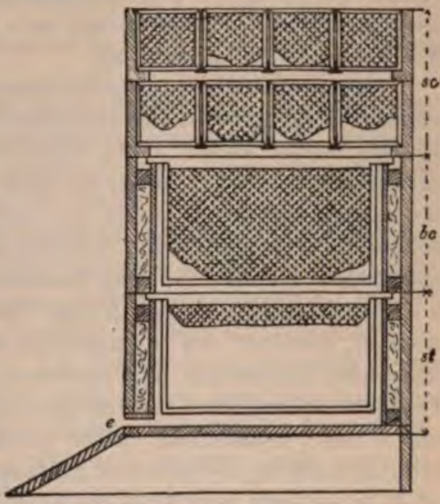


FIG. 8.—The Simmins nonswarming system—double-story hive with supers: *bc*, brood chamber; *sc*, supers; *st*, chamber with starters of comb foundation; *e*, entrance.

## SPECIAL CROPS FOR HONEY ALONE NOT PROFITABLE.

With a small apiary, planting for honey alone certainly can not be made profitable. Small plats of honey-producing plants are valuable mainly because they afford an opportunity of observing when and under what circumstances the bees work on certain blossoms, and for the purpose of determining what might be depended upon to fill a gap in the honey resources of a given locality whenever the size of the apiary might make this a consideration of some importance. Even with a large apiary probably no case exists in which, in the present condition of the subject, planting for honey alone would prove profitable. But when selecting crops for cultivation for other purposes, or shrubs and trees for planting, the bee keeper should of course choose such as will also furnish honey at a time when pasturage for his bees would otherwise be wanting.

As complete a list as possible should be made of the plants and trees visited by honeybees, and notes should be added as to period of blossoming, importance of yield, whether honey or pollen or both of these are collected, quality of the product, etc. If gaps occur during which no natural forage abounds for the bees, some crop can usually be selected which will fill the interval, and, while supplying a continuous succession of honey-yielding blossoms for the bees, will give in addition a yield of fruit, grain, or forage from the same land. The novice is warned, however, not to expect too much from a small area. He must remember that as the bees commonly go 2½ to 3 miles in all directions from the apiary, they thus range over an area of 12,000 to 18,000 acres, and if but 1 square foot in 100 produces a honey-yielding plant they still have 120 to 180 acres of pasturage, and quite likely the equivalent of 30 to 40 acres may be in bloom at one time within range of the bees. A few acres more or less at such a time will therefore not make a great deal of difference.

But if coming between the principal crops—especially if the bees, as is often the case, would otherwise have no pasturage at all—the area provided for them may be of greater relative importance than the larger area of natural pasturage; for it frequently occurs that the smaller part only of the honey produced by the field over which the bees of an apiary range can be collected by them before it is washed out by rains, or the liquid portion is evaporated and the blossoms withered, while a smaller area may be more assiduously visited, and, the nectar being gathered as fast as secreted, a greater yield per acre may result.

It is further of some importance to fill in such a gap with something to keep the bees busy, instead of letting them spend their time trying to rob one another; and, what is probably even more important, the pasturage thus furnished will keep up brood rearing and comb building and assist materially in preparing the colonies for the succeeding honey flow.

There are many plants and trees of economic value, in addition to their production of honey, which may be utilized in one portion or another of the United States in the manner indicated. Adaptability to climate and soil, the periods of honey dearth to be filled in, markets for the crop produced, etc., must all come in to influence the choice. The following list includes the more important plants of economic value in this country which are good honey and pollen yielders. Most of those named are adapted to a considerable portion of the Union. Except in the case of plants restricted to the South, the dates given are applicable, in the main, to middle latitudes.

## ECONOMIC PLANTS AND TREES FOR CULTIVATION FOR HONEY AND POLLEN.

**Filbert bushes**, useful for wind-breaks and for their nuts, yield pollen in February and March.

**Rape** can be grown successfully in the North for pasturage, for green manuring, or for seed, and when permitted to blossom yields considerable pollen and honey. Winter varieties are sown late in the summer or early in the autumn, and blossom in April or May following. This early yield forms an excellent stimulus to brood rearing. Summer or bird rape, grown chiefly for its seed, blossoms about a month after sowing. It does best during the cooler months of the growing season.

**Russian or hairy vetch** is a hardy leguminous plant of great value for forage and use in green manuring. The blossoms appear early in the season, and, where there is any lack in early pollen, especially in northern and cool regions, this vetch will be found of great value to the bees.

**Fruit blossoms**—apricot, peach, pear, plum, cherry, apple, currant, and gooseberry—yield pollen and honey in abundance during April or May; strawberry and blackberry are sometimes visited freely by bees, but are generally far less important than the others mentioned. Colonies that have wintered well often gather during apple bloom 12 to 15 pounds of surplus honey of fine quality. The raspberry secretes a large amount of nectar of superb quality, and coming in May or June, thus later than the other fruit blossoms and when the colonies are stronger and the weather is more settled, full advantage can nearly always be taken of this yield. Grape and persimmon blossom also in June; the latter is an excellent source. In subtropical portions of the country orange and lemon trees yield fine honey in March and April, and the cultivation of the banana has added a profuse honey yielder which puts forth successive blossoms all through the summer months.

**Locust, tulip tree** ("poplar," or whitewood), and **horse-chestnut**, useful for shade, ornament, and timber, are all fine honey producers in May. The locust yields light-colored, clear honey of fine quality, the others amber-colored honey of good body and fair

**Clovers.**—Crimson, blossoming in April or May, yields fine, light-colored honey; white, alsike, and mammoth or medium, blossoming in May, June, and July, give honey of excellent quality and rich yellow color.

**Mustard** grown for seed flowers from June to August. The honey is somewhat acrid and crystallizes soon, yet the plant, where abundant, is of much importance to the bees and the bee keeper in case other forage is scant at the time.

**Asparagus** blossoms are much visited by bees in June and July.

**Esparcet**, or **sainfoin**, yields in May and June fine honey, almost as clear as spring water. It is a perennial leguminous plant, rather hardy, an excellent forage crop, and particularly valuable for milch cows. It succeeds best on a limestone soil or when lime is used as a fertilizer, and is itself an excellent green manure for soils deficient in nitrogen and phosphoric acid.

**Sulla, or sulla clover,** a perennial plant, closely related to esparcet or sainfoin, succeeds, like the latter, best upon limestone soil or when fertilized with lime. It yields a splendid quality of honey from beautiful pink blossoms, which continue during May and June. The plant is an excellent soil fertilizer and of great value in connection with the feeding of stock, particularly dairy animals. It is, however, much less hardy than esparcet, and success with it can therefore hardly be looked for above the latitude of North Carolina and Arkansas. When the qualities and requirements of this plant were brought by the writer to the notice of a prominent scientific agriculturist of the South, this gentleman suggested as very probable that the black belt of Alabama, Mississippi, Louisiana, and Texas would be well adapted to it, the lands of this region being exceedingly strong in lime. In portions of southern Europe sulla clover is a most important forage crop for farm stock as well as for honey bees.

**Serradella** is an annual leguminous plant which will grow on sandy land, and which yields, besides good forage, clear honey of good quality in June and July.

**Chestnut**, valuable for timber, ornament, shade, and nuts, yields honey and pollen in June or July.

**Linden, sourwood**, and **catalpa**, fine shade, ornamental, and timber trees, yield great quantities of first quality honey in June and July.

**Cotton.**—In the South cotton blossoms, appearing as they do in succession during the whole summer, often yield considerable honey. It would appear, however, that when the plants are very rank in growth the blossoms—being correspondingly large—are too deep for the bees to reach the nectar.

**Chicory**, raised for salad and for its roots, is, whenever permitted to blossom, eagerly visited for honey in July and August.

**Sweet, medicinal, and pot herbs,** such as marjoram, savory, lavender, ip, balm, sage, thyme, etc., when allowed to blossom, nearly all yield ey in June, July, or August. Where fields of them are grown for seed the honey yield may be considerable from this source.

**lfalfa** furnishes in the West a large amount of very fine honey dur- June and July. Its importance there as a forage crop is well wn, but how far eastward its cultivation may be profitably extended ill a question, and even should it prove of value in the East as a ge plant, its honey-producing qualities there would be still ertain.

**arsnips**, when left for seed, blossom freely from June to August, usive, and are much frequented by honey bees.

**eppermint**, raised for its foliage, from which oil is distilled, is most uently cut before the bees derive much benefit from it, but when- allowed to blossom it is eagerly sought after by them, and yields ey freely during July and August.

**okhara**, or **sweet clover**, is in some sections of the country consid- a valuable forage crop. Animals can be taught to like it, and it ery valuable as a restorer of exhausted lime soils, while in regions ing in bee pasturage during the summer months it is a very ortant addition. It withstands drought remarkably well and yields ge quantity of fine honey.

**ucumber, squash, pumpkin,** and **melon** blossoms furnish honey and e pollen to the bees in July and August.

**ucalypti**, valuable for their timber and as ornaments to lawn and lside, are quick-growing trees adapted to the southern portions of United States. They yield much honey between July and October.

he **carob tree**, whose cultivation has been commenced in the South- t, is an excellent honey yielder in late summer. It is an ornamental and gives, in addition to honey, another valuable product—the b bean of commerce.

**caline**, a forage and ornamental plant of recent introduction, is a t favorite with bees. It blossoms profusely during August, is a ly perennial, and thrives in wet and also fairly in dry situations, standing the ordinary summer drought of the Eastern States use of its deeply penetrating roots.

**ckwheat** is an important honey and pollen producer. Its blossoms ear about four weeks after the seed is sown, hence it may be made ll in a summer dearth of honey plants.

## HOW TO OBTAIN SURPLUS HONEY AND WAX.

ood wintering, followed by careful conservation of the natural nth of the colony, the presence of a prolific queen—preferably a ng one—with abundant stores for brood rearing, are, together with prevention, in so far as possible, of swarming, the prime conditions ssary to bring a colony of bees to the chief honey flow in shape to enable it to take full advantage of the harvest. In addition it is only necessary to adjust the surplus honey receptacles in time, making the space given proportionate to the strength of the colony, and, while continuing to prevent as far as possible the issuance of swarms, to remove the accumulated honey fast enough to give abundant storage room.

### EXTRACTED HONEY.

To secure extracted honey, the requisite number of combs may be in one long hive, or in stories one above another. Preference is most generally given to the latter plan. The brood apartment is made in this case to hold eight to twelve Langstroth frames, and a second, and sometimes a third or even a fourth story, may be added temporarily. These added stories may be for full-depth frames, or, for convenience in handling and in order to be able to control more closely the amount of space given, they may be half the usual depth, and but one of the half-depth stories added at a time. If numerous sets of combs are at hand, or if it is desirable to have others built, additional stories are put on as fast as the combs already occupied by the bees are filled. Before removing the filled combs time should be allowed the bees to ripen and cap the honey; hence enough combs are necessary to give the bees storage room while they are capping others. The honey in combs that are quite or nearly sealed over may be considered sufficiently ripened to be removed from the hive.

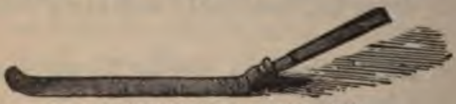


Fig. 9.—Quinby uncapping knife.

It should also be taken promptly, in order to keep the various grades or kinds separate. However, when the combs of a given super are completely filled and sealed it may be marked and left on the hive if more convenient to be extracted later.

The cells are uncapped by means of a sharp knife, made especially for this purpose (fig. 9), and the combs are then made to revolve rapidly in the honey extractor (fig. 10). The centrifugal force exerted on the honey throws it out, leaving the comb cells uninjured, or so slightly injured that they are wholly repaired within an hour or so after the return of the comb to the hive. The chief advantages of this method of harvesting over that of crushing the combs are at once apparent when it is known that each pound of comb saved represents several pounds of honey (consumed in its construction), and may, with care be used over almost indefinitely in securing surplus honey. Furthermore, extracted honey is of much finer quality than that obtained by crushing the combs and straining out the liquid part, since it is free from crushed bees, larvæ, pollen or "bee bread," etc., which not only render strained honey dark and strong in flavor, but also make it liable to fermentation and souring.

The extracted honey is run into open buckets or tanks and left, ered with cheese cloth, to stand a week or so in a dry, warm room frequented by ants. It should be skimmed each day until per-tly clear, and is then ready to be put into cans or barrels for rketing, or to be stored in a dry place. Square tin cans, each made hold 60 pounds of extracted honey, are sold by dealers in apiarian plies. This style of package is a convenient one to transport, and lso acceptable to dealers. Wooden shipping cases are usually con-icted so as to hold two of these cans. Barrels and kegs may be d, especially for the cheaper grades of honey used chiefly in the nufacture of other articles. They should be dry, made of well-soned, sound wood, and the hoops driven tight and secured, as l-ripened honey readily absorbs moisture from wood, causing nkage and leakage. They should also be coated inside with bees- or paraffin. This is easily done by warming the barrels and then ring in a gallon or two of hot wax paraffin, and, after having driven the bungs tightly, rolling the bar- about a few times and turning m on end. The work should be ne quickly and the liquid not ad-ring to the inner surfaces poured t at once, in order to leave but a n coating inside.

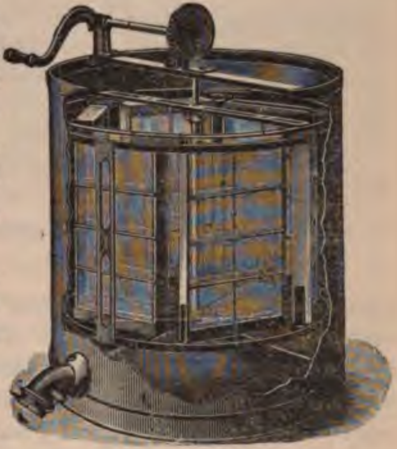


FIG. 10.—Automatic reversible honey extractor.

The surplus combs are to be re-ved at the close of the season and ng an inch or so apart on racks ced in a dry, airy room, where no ificial heat is felt. Mice, if permit- to reach them, will do consider-e damage by gnawing away the cells taining pollen or those in which s have been bred, and which therefore contain larval and pupal skins. th larvæ are not likely to trouble them until the following spring, upon the appearance of milder weather their ravages will begin, and he combs can not be placed under the care of the bees at once they st be fumigated with burning sulphur or with bisulphide of carbon.

## COMB HONEY.

The main difference to be observed in preparing colonies for the oduction of comb honey, instead of extracted, is in the adjust-ent of the brood apartment at the time the supers are added. After colony has been bred up to the greatest possible strength, the od apartment should be so regulated in size, when the honey flow gins and the supers are added, as to crowd many of the bees out and o the supers placed above.

On each hive a super is placed (fig. 11) holding 24 to 48 sections, each section supplied with a strip or a full sheet of very thin foundation. It is best not to give too much space at once, as considerable warmth is necessary to enable the bees to draw out foundation or to build comb. A single set of sections is usually sufficient at a time. When the honey is designed for home use or for a local market, half-depth frames are sometimes used, the same as those often used above the brood nests when colonies are run for extracted honey, but for the general market pound sections (fig. 12) are better adapted.

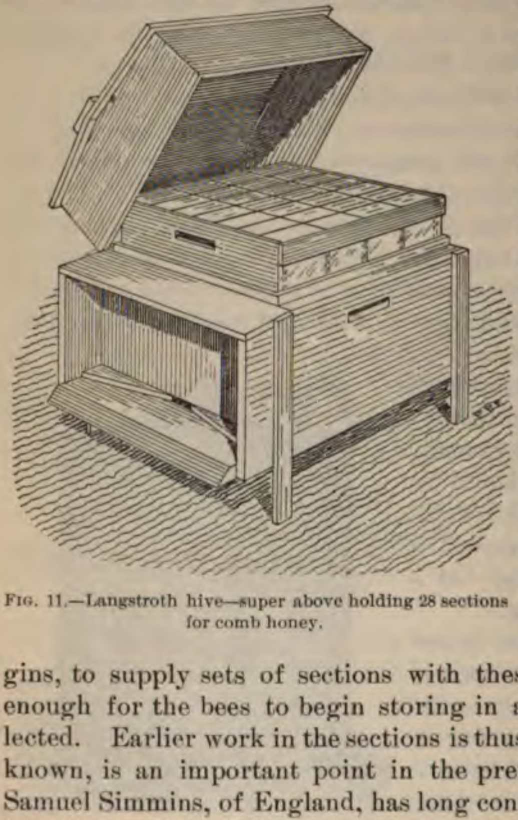


FIG. 11.—Langstroth hive—super above holding 28 sections for comb honey.

It is the practice of many to have nice white comb partially drawn out before the main honey flow begins, or even the season before, feeding the colonies, if necessary, to secure this; and, when the honey yield begins, to supply sets of sections with these combs having cells deep enough for the bees to begin storing in as soon as any honey is collected. Earlier work in the sections is thus secured, and this, as is well known, is an important point in the prevention of swarming. Mr. Samuel Simmins, of England, has long contended for this use of partially drawn combs, and though it forms a feature of his system for the prevention of swarming it has been too often overlooked. Comb foundation is now manufactured with extra thin septum or base and with the beginnings of the cells marked out by somewhat thicker walls which the bees immediately thin down, using the extra wax in deepening the cells. This is not artificial comb, but a thin sheet of wax having the bases of the cells outlined on it. Complete artificial combs have never been used in a commercial way, although there exists a widespread belief to this effect, which is founded on extravagant claims that have appeared from time to time in newspaper articles.

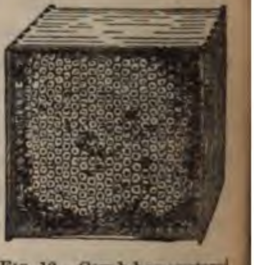


FIG. 12.—Comb honey stored in pound section—size 4¼ by 4¼ inches.

*If the* brood apartment has been much contracted when the supers

ıd, the queen may go into the sections and deposit eggs
vented by the insertion of a queen excluder (fig. 13). This,
sheet of zinc with perforations which permit workers, but
een, to pass, is placed between the brood apartment and the
The great inconvenience of having brood in some of the sec-
ereby prevented. When the honey in the sections has been
ɔped over, the super may be lifted up and another added
and the brood apartment. Or, should the strength of the
be sufficient, or the harvest not abundant enough to war-
iving of so much space, the sections which are completely
ıay be removed and the partly finished ones used as "bait
to encourage work in another set of sections on this hive or
ɔers elsewhere. The objections to the removal of sections
, and brushing the bees from them, are (1) the time it takes,
e danger that the bees when disturbed, and especially if
ill bite open the capping and be-
noval of the honey, thus injuring
ance of the completed sections.
ıt valuable invention, the bee es-
), the use of which is explained on
ınd 16, when placed between the
the brood nest, permits the bees
e the escape to go down into the
rtment, but does not permit their
the super. If inserted twelve
four hours before the sections are
ved, the latter will be found free
at the time of removal, provided
has been kept out of the supers.

**and shipping comb honey.**—Be-
eting the honey it should be care-
ed, and all propolis ("bee-glue"),
any, scraped from the edges of the sections. In grading for
arkets the following rules are, in the main, observed. They
ıted by the North American Bee-Keepers' Association at its
ird annual convention, held in Washington, D. C., in Decem-
and are copied from the official report of that meeting:

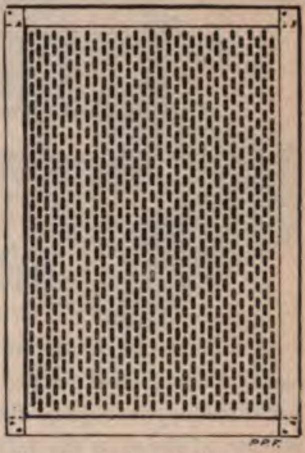


FIG. 13.—Perforated zinc queen-excluder.

ll sections to be well filled; combs straight, of even thickness, and firmly
all four sides; both wood and comb unsoiled by travel stain or other-
ls sealed except the row of cells next to the wood.

l sections well filled, but with combs crooked or uneven, detached at the
ith but few cells unsealed; both wood and comb unsoiled by travel stain
.

n to the above, honey is to be classified, according to color, into light,
dark. For instance, there will be "fancy light," "fancy amber," and
," "No. 1 light," "No. 1 amber," and "No. 1 dark."

The sections, after grading and scraping, are to be placed in c
shipping cases having glass in one or both ends (fig. 14). Severa
these may be placed in a single crate for shipment. To prevent br
ing down of the combs it is best to put straw in the bottom of the c
for the shipping cases to rest on, and the crates should be so place
to keep the combs in a perpendicular position. The crates are
likely to be kept right side up if convenient handles are attached to
sides—preferably strips with the ends projecting beyond the corn
Care in handling will generally be given if the glass in the shipp
cases shows.

Owing to the appearance of statements of a sensational characte
the effect that complete honey combs are manufactured by machi
and filled with sweets lower in price than honey (glucose, cane su
or mixtures of these), then sealed over and sold in the mark
genuine honey, a strong suspicion exists regarding the comb h
commonly offered for sale. Wide circulation has been given to
wild stories by sensat
newspaper writers, and
monthly periodicals, us
far more discriminatin
accurate, have rep
them. Some writers
even tried to locat
"comb-honey factori
given cities, but inv
tion has always show
the locations were
ical. The forfeit of $1,000 which a reputable firm has had st
for fifteen years past for a pound of manufactured comb hon
nature to deceive the buyer still remains unclaimed.

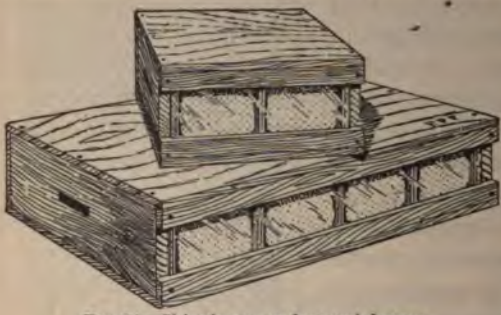


FIG. 14.—Shipping cases for comb honey.

The National Bee-Keepers' Association, at its annual conventi
in St. Louis in 1904, offered also a like forfeit of $1,000 for s
tory proof of the existence of such a thing as manufacture
honey. But no claimant has come forward, notwithstandi
$2,000 which awaits his proof. The fact is, there is no trut
"yarn," and no one has thus far shown the thing possible. Th
honey in the markets is pure and wholesome—a healthful an
ishing sweet, easier to digest than cane sugar or any of the
so commonly sold. It is worth a place on the tables of all w
afford to use it.

## PRODUCTION OF WAX.

No method has yet been brought forward which will enable
the present relative prices of honey and wax, to turn the whole
ing force of the bees, or even the greater part of it, into the p

ax instead of honey; in fact, the small amount of wax produced lly in apiaries managed for extracted or for section honey is urned into honey the following season; that is, it is made foundation, which is then employed in the same hives to heir yield of marketable honey. It is even the case that in ries managed on approved modern methods more pounds of n are employed than wax ; hence less progressive ers—those who adhere to f box hives and who can fore utilize comb founda- called upon for their wax As each pound of wax s several pounds of honey, ngs removed when prepar- bs for the extractor, all and trimmings and bits of mb, are to be saved and into wax. This is best he solar wax extractor (fig. essential parts of which are a metal tank with wire-cloth and a glass cover, the latter generally made double. The f the metal tank is strewn with pieces of comb, the glass usted, and the whole exposed to the direct rays of the sun. A quality of wax filters through the strainer.

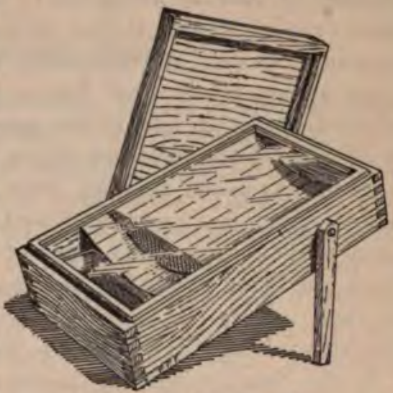
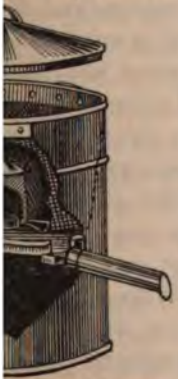


FIG. 15.—Solar wax-extractor.



am wax-extractor.

Another method is to inclose the cappings or combs to be rendered in a coarse sack and weight this down in a tin boiler partly filled with rain water or soft spring water and boil slowly until little or no more wax can be pressed out of the material in the sack. Melting in an iron receptacle makes the wax dark colored. A special utensil made of tin, for use as a wax-extractor (fig. 16) over boiling water, can also be had. The bits of comb are placed in this, in an inside can having fine perforations, through which the steam from below enters and melts out the wax, which drips pout into another receptacle partly filled with water, from ce of which the cake of wax may be removed when cold.

## THE WINTERING OF BEES.

bring bees successfully through the winter in the colder por- the United States is a problem which gives anxiety to all about to attempt it for the first time in those sections, and even many who have kept bees for years still find it their greatest difficulty. It may happen occasionally that a queen, apparently young and vigorous in the autumn, will die during the winter, when a young one can not be reared, and as a result the colony will dwindle away. Such losses are, however, rare, and, aside from the possible results of fire, flood, or violent storms, are about the only ones which can not be avoided by careful attention to right methods in wintering. Insufficient or poor winter stores, hives faulty in construction, lack of protection from cold and dampness, too much or too little ventilation, too great a proportion of old bees or too great a proportion of young ones, overmanipulation late in the season, etc., are the most important and most easily detected causes of loss in wintering bees. In some instances colonies supposed to have been placed in the same condition under which others have wintered well become diseased and die or dwindle away without prominent signs of disease. It is evident, however, that some condition existed in one case which was not present in the other, or that, in spite of some unfavorable condition, the favorable ones combined, in the first instance, to render the wintering successful.

In the South wintering in the open air on the summer stands is the only method followed, while in the colder portions of the country, although with proper precautions bees may be wintered successfully in the open air, many prefer to house them in special repositories built with double walls, or to place them in darkened cellars, or in clamps. Indoor wintering should be confined to regions where there are several weeks, at least, of continued severe weather. When all conditions are right, consumption of honey will be less indoors and loss of bee life less than with the methods usually practiced in outdoor wintering. Under proper conditions, however, especially when abundant protection has been given, colonies out of doors will consume no more food nor meet with greater losses in numbers than those wintered under favorable conditions indoors. In wintering indoors certain essential conditions are, in a measure, beyond the control of the bee keeper, hence must be left to chance, and certain other conditions and emergencies liable to arise, though easily understood and met by the man of experience in this direction, are yet very likely to be overlooked by the novice or to be puzzling and disastrous to him. For these reasons it is safer for him to keep closer to the natural method at first and try outdoor wintering.

In wintering out of doors the conditions within the control of the bee keeper are more readily perceived and easier to meet, and though the original work of preparation for good wintering out of doors is greater per colony, yet the work during the winter itself and the following spring is likely to be less; moreover, the feeling of greater security, as well as the greater certainty of finding the colonies in good condition to begin gathering in the spring, are points well worthy of consideration. In other words, indoor wintering should be left to such experienced bee keepers as may prefer it and are located in cold climates, while novices, wherever located, should first endeavor to meet the requirements of successful outdoor wintering; that is, to prepare the colonies so that Nature, whatever her mood as regards the weather, will bring her tiny charges safely through the perils and vicissitudes of the winter months.

## GENERAL CONSIDERATIONS.

Whatever method be followed in wintering, certain conditions regarding the colony itself are plainly essential: First, it should have a good queen; second, a fair-sized cluster of healthy bees, neither too old nor too young; third, a plentiful supply of good food. The first of these conditions may be counted as fulfilled if the queen at the head of the colony is not more than two years old, is still active, and has always kept her colony populous; yet a younger queen—even one of the current season's rearing, and thus but a few weeks or months old—is if raised under favorable conditions, much to be preferred. The second point is met if brood rearing has been continued without serious interruption during the latter part of the summer and the cluster of bees occupies, on a cool day in autumn, six to eight or more spaces between the combs, or forms a compact cluster 8 or 10 inches in diameter. Young bees, if not well protected by older ones, succumb readily to the cold, while quite old bees die early in the spring, and others, which emerged late in the summer or autumn preceding, are needed to replace them. The third essential—good food—is secured if the hive is liberally supplied with well-ripened honey from any source whatever, or with fairly thick sirup, made from white cane sugar, which was fed early enough to enable the bees to seal it over before they ceased flying. The sirup is prepared by dissolving 3 pounds of granulated sugar in 1 quart of boiling water and adding to this 1 pound of pure extracted honey. Twenty to 25 pounds for outdoor wintering in the South, up to 30 or 40 pounds in the North, when wintered outside with but slight protection—or, if wintered indoors, about 20 pounds—may be considered a fair supply of winter food. A smaller amount should not be trusted except in case much greater protection be furnished against the effects of severe weather than is usually given. A greater amount of stores will do no harm if properly arranged over and about the center of the cluster, or, in case the combs are narrow, wholly above the cluster. In many instances it will be a benefit by equalizing in a measure the temperature in the hive, as well as by giving to the bees greater confidence in extending the brood nest in early spring.

## INDOOR WINTERING.

A dry, dark cellar or special repository built in a sidehill or with double, filled walls, like those of an ice house, may be utilized for wintering bees in extremely cold climates. It should be so built that a temperature of 42° to 45° F. (the air being fairly dry in the cellar) can be maintained during the greater part of the winter. To this end it should be well drained, furnished with adjustable ventilators, and covered all over with earth, except the entrance, where close-fitting doors, preferably three of them, should open in succession, so as to separate the main room from the outside by a double entry way. The colonies, supplied with good queens, plenty of bees, 20 to 25 pounds of stores each, and with chaff cushions placed over the frames, are carried in shortly before snow and severe freezing weather come.

Any repository which is damp or one whose temperature falls below freezing or remains long below 38° F. is not a suitable place in which to winter bees. When in repositories, the bees have no opportunity for a cleansing flight, nor do they, when the temperature rises outside, always warm up sufficiently to enable the cluster to move from combs from which the stores have been exhausted to full ones; hence in a cold repository they may possibly starve with plenty of food in the hive. As a rule, colonies would be better off out of doors on their summer stands than in such places.

## OUTDOOR WINTERING.

Cold and dampness are the great winter enemies of bee life. A single bee can withstand very little cold, but a good cluster, if all other conditions are favorable, can defy the most rigorous winters of our coldest States. But if not thoroughly dry, even a moderate degree of cold is always injurious, if not absolutely fatal. Dampness in winter is therefore the most dangerous element with which the bee keeper has to contend. The matter would, of course, be quite simple if only that dampness which might come from the outside were to be considered, but when the air of the hive, somewhat warmed by the bees and more or less charged with the moisture of respiration, comes in contact with hive walls or comb surfaces made cold by outside air, condensation takes place, and the moisture trickles over the cold surfaces and cluster of bees, saturating the air about them or even drenching them, unless by forming a very compact cluster they are able to prevent it from penetrating, or by greater activity to raise the temperature sufficiently to evaporate the surplus moisture, or at least that portion near them. But this greater activity is, of course, at the expense of muscular power and requires the consumption of nitrogenous as well as carbonaceous food. Increased cold or its long continuance greatly aggravates conditions.

Nature has provided that the accumulation of waste products in the body of the bee during its winter confinement should be small under normal conditions, but unusual consumption of food, especially of a highly nitrogenous nature like pollen, necessitates a cleansing flight, or diarrheal difficulties ensue, combs and hives are soiled, the air of the hive becomes polluted, and at last the individual bees become too weak to generate proper warmth or drive off the surplus moisture which then invades the cluster and brings death to the colony; or, what is more frequently the case, a cold snap destroys the last remnant of the colony, which has been reduced by constant loss of bees impelled by disease to leave the cluster or even to venture out for a cleansing flight when snows and great cold prevail.

The problem then is: *To retain the warmth generated by the bees, which is necessary to their well-being, and at the same time to prevent the accumulation of moisture in the hive.* A simple opening at the top of the hive would permit much of the moisture to pass off, but of course heat would escape with it and a draft would be produced. Absorbent material about the cluster creates, without free ventilation, damp surroundings, and again the temperature is lowered. It is only necessary, however, to surround the bees with sufficient material to protect them fully against the greatest cold likely to occur, and to take care also that this enveloping material is of such a nature and so disposed as to permit the free passage of the moisture which would otherwise collect in the interior of the hive, and to permit the escape into the surrounding atmosphere of such moisture as enters this material from within. This packing should also be fully protected from outside moisture.

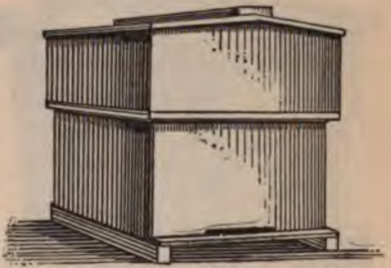


FIG. 17.—Double-walled hive adapted to outdoor wintering as well as summer use below 40° north latitude in the United States. Thickness of each wall, ⅞ inch, space between walls, 2 inches, packed with dry chaff or ground cork.

South of Virginia, Kentucky, and Kansas single-walled hives may be employed in most localities with good success in outdoor wintering. On the approach of the cool or the rainy season a close-fitting quilt should be laid over the frames and several folded newspapers pressed down on this, or a cushion filled with dry chaff or some other soft material may be used instead of paper. The cover or roof should be absolutely rain proof, yet between this cover and the cushion or papers should be several inches of space with free circulation of air. In order to permit this ventilation above the top packing, the cover should not rest upon the cap or upper story all of the way around, or if it does, an auger hole in each end, protected by wire cloth against the entrance of mice, should give free passage to the air. In the more northern portion of the section referred to some further protection is advisable (fig. 17), and is really necessary in the mountainous parts of the same territory if the best results are to be obtained. Farther north, and especially in the cold Northwest, much greater protection becomes an absolute necessity. Quilts with newspapers or thin packing above do not alone suffice. The side walls of the hive may be made of pressed straw (fig. 18). These, with top packing, if kept dry outside, are excellent for outdoor wintering, even in climates so cold that ordinary wooden hives do not afford sufficient protection.

In the severest climates, however, still greater protection on all sides of the colony is needed, and packing with chaff or other soft material is decidedly the best plan. The thickness of this surrounding packing should be from 2 inches to 8 or 10 inches for single colonies, according to the severity of the climate, but if four or more colonies are grouped for the winter, so as to make the natural warmth generated mutually advantageous, somewhat less packing will be sufficient. A most important point is to have the soft warmth-retaining packing come in close contact with the edges of the combs, and above all *not to have a hive wall, either thick or thin, between this material and the bees.* A good plan is to construct an open framework or skeleton hive of laths, cover it with sacking, or, preferably, some less fuzzy cloth which the bees will not gnaw, and after placing it in an outer wooden case large enough every way to admit of the necessary packing about the colony, to fill in on all sides with some dry, porous material (fig. 19). If the frames are shallow, like the Langstroth, it is better to construct the inner case so as to place them on end, and thus give a deeper comb for the winter. Layers of newspapers may come next outside the cloth covering of the framework. Wheat chaff answers well to complete the packing. Wool is to be preferred, but is of course too expensive unless a waste product. Ground cork, waste flax, hemp, sawdust, etc., in fact, any fine porous material, if thoroughly dry, may be used.

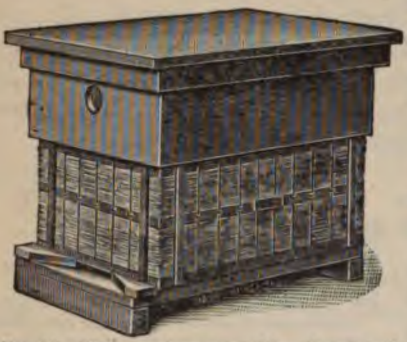


FIG. 18.—The American straw hive (Langstroth principle) of Hayck Brothers.

A board passageway 3 or 4 inches wide and three-eighths of an inch high should connect this inner apartment and the flight hole of the outer case, thus affording an exit for the bees whenever the weather may permit them to fly. When these preparations have been completed, the hive is ready for the combs, which, with adhering bees, are taken from the summer hive and inserted in the winter hive. A quilt is then laid on the frames and the top packing put on. This, for convenience, may be held in a cloth-bottomed tray. It is quite important, as already mentioned, that air be allowed to circulate freely above the packing. The outside case must be quite rain-proof or else wholly protected from the rain by a roof.

All other necessary conditions having been complied with shortly after the gathering season closed, the combs may be lifted from the summer hives and placed in these specially arranged winter cases before cold weather wholly stops the bees from flying out. Thus prepared for the winter the colonies will need but slight attention from October until March, or, in the North, even later, and the losses will be limited to the small percentage of cases due to failure of apparently good queens.

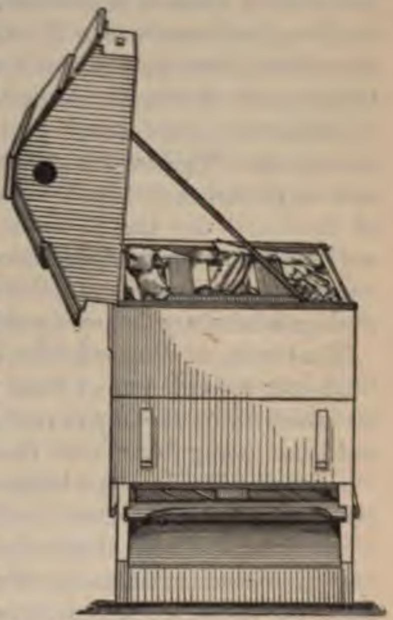


FIG. 19.—Colony of bees with newspapers packed between inner and outer cases and brood frames on end for the winter.

## THE RISK OF LOSS THROUGH DISEASE AND ENEMIES.

Winter losses through disease superinduced by unfavorable surroundings which it is within the power of the bee keeper to avoid have already been considered. But one other very serious disease has been widespread.

### FOUL BROOD OR BACILLUS OF THE HIVE.

This is a highly contagious affection which, as it mainly affects the developing brood in the cells, is commonly known as "foul brood." It is due to a microbe (*Bacillus alvei*) whose spores are easily transported from hive to hive by the bees themselves, by the operator, in honey, or in combs changed from one hive to another. Once established in an apiary, it usually spreads, unless speedily and energetically checked, until all of the colonies in the neighborhood are ruined and even exterminated. The most apparent symptoms are the turning black of larvæ in open cells, many sealed cells with sunken caps, frequently broken in and containing dead larvæ or pupæ in a putrid condition, brown or coffee-colored, jelly-like or ropy in consistency, and giving off an offensive odor. The disease, though known to exist in nearly all countries, can hardly be said to be common. The writer, in an experience of over thirty years in bee keeping in several States of the Union, as well as in a number of foreign countries, has met the disease but rarely, and has had but one experience wi apiary, it having been in this instance brought in by a neighbor who purchased bees at a distance. It was easily cured, without great loss. Thus the beginner's risks of disaster in this direction are, if he be forewarned, comparatively small. He may, furthermore, gain assurance from the fact that, should the disease invade his apiary, prompt and intelligent action will prevent serious loss.

The following is the treatment for a colony which still has sufficient strength of numbers to be worth saving: The bees are to be shaken from their combs just at nightfall into an empty box, which is to be removed at once to a cool, dark place. They are to be confined to the box, but it must be well ventilated through openings covered with wire cloth. During the first forty-eight hours no food should be given to them, and during the second forty-eight hours only a small amount of medicated sirup—a half pint daily for a small colony to a pint for a strong one. This food is prepared by adding one part of pure carbolic acid or phenol to 600 or 700 parts of sugar sirup or honey. At the end of the fourth day the bees are to be shaken into a clean hive supplied with starters of comb foundation. This hive is to be placed outside on a stand some distance from all other colonies, and moderate feeding with medicated sirup or honey should be continued for a few days thereafter.

The combs of diseased colonies which contain brood may be assembled over a single one of these colonies, or, if the amount of brood be too great for one colony to care for, over several such diseased colonies, until the young bees have emerged. All of the honey is then to be extracted. While it is wholesome as food, it should not be offered for sale, lest some of it be used in feeding bees or be inadvertently exposed where foraging bees might find it and carry to their hives the germs of this disease, harmless to other creatures but so fatal to bee life. A good use for this honey is to employ it in making vinegar. One and one-third pounds added to each gallon of rain water or soft spring water and allowed to ferment for three months in a warm place makes a quality of vinegar quite equal to the best cider vinegar. Provision for the free circulation of air through the cask should be made. This is easily secured by placing the cask, not completely filled, on its side and boring an auger hole in each end near the upper side, the holes to be covered with cheese cloth or fine gauze, to keep out insects.

If the honey containing the germs is to be used for feeding bees, it is to be diluted with half its own quantity, by measure, of water and kept at the boiling point for three hours in a water bath—a vessel within another containing water.

The combs from which the honey has been extracted, as well as all of the pieces built by the bees during their four days' confinement, may be melted into wax, by thorough boiling in soft water. This wax should be kept liquid for 48 hours or longer, to allow all impurities to settle. These will include the foul brood spores, which may en be removed with the impure wax by scraping or cutting away e bottom of the cake. These scrapings should be burned. The ne disposition had better be made of the frames from which the nbs containing germs were removed.

In all of this work the utmost care should be exercised to avoid the pping of honey about the apiary or the exposure of implements, ceptacles, or combs smeared with or containing honey from the eased colonies. It may even be better, in order to save time and ssible risk, where but few combs and a comparatively small amount honey are involved, to destroy all of these immediately after their moval from the hive. The old hive and all utensils used about the eased colony should be disinfected by washing in a solution of cor-ive sublimate—one-eighth ounce in one gallon of water—and should erwards be exposed to the air and sun for some time. If healthy onies are to be manipulated immediately after handling diseased ones hands of the operator must also be disinfected by washing in the ution just mentioned.

Those who care to try and save combs and brood should employ the medial method developed by the late Professor Cheshire. This is plained in full in his work on bee keeping,[a] and a brief statement of may also be found in "The Honey Bee," Bulletin No. 1, new series, the Bureau of Entomology, United States Department of Agri-lture. Notwithstanding these remedies, some will prefer, where althy colonies of bees can be bought at moderate prices, to burn seased bees, combs, and frames rather than spend time to effect a re, and risk, as they fear they may, the further spread of the pest. kill the bees thus is, however, neither profitable, humane, nor neces-ry, for if confined as described above and separated at once from the her colonies, this work being done at nightfall, when all of the bees e in their hives, the risk of spreading the disease will not thereby increased, nor is the labor much greater than that involved in the moval of combs and bees for burning. And if it be found that the eased colonies are weak in numbers and seem, therefore, individually rdly worth saving, this need not be taken as an excuse for the death ntence, as several colonies may be smoked and shaken together o the same box to make a single strong colony, the best queen of the having been selected and caged in the box in such a way that the rkers can release her within a few hours by eating through candy.

### BEE PARALYSIS.

Among other diseases of a bacterial nature paralysis is most notice-le, although not to be dreaded as foul brood. It affects the adult es only, producing a paralyzed condition of their members and a swelling up of their bodies. The diseased bees, often set upo other workers, lose the hairy covering of their bodies, and, black shiny in appearance, may often be seen wriggling away from hives to die. In such cases the working force of the affected frequently becomes so greatly reduced as to preclude any retu the form of honey or swarms during the given season. The from which the bees obtain the original infection is unknown, once in the apiary, it is spread mainly by the entrance of affe workers into healthy colonies, and probably also by the visits w bees from healthy colonies make to the diseased ones, the latter being so weakened in numbers as to be unable to protect their from healthy bees out on robbing expeditions.

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[a] "Bees and Bee keeping," by Frank R. Cheshire, F. L. S., F. R. M. S., London, 88, Vol. II, pages 554–575.

Ordinary paralysis may generally be cured by strewing powd sulphur over the combs, bees, and along the top bars of the fra the precaution first having been taken of removing all unsealed br This brood would be killed by the application of sulphur, but as t is no danger whatever of spreading the disease by the transfer of b or honey from one hive to another, provided absolutely every o the adult bees has first been shaken or brushed from the combs, latter may be given to healthy colonies which need strengthening.

Another simple plan for getting rid of the disease and yet utili the available strength of the affected colonies is to close their hiv night and move them a mile or more, locating them, if poss outside of the range of other bees. As the brood in these col remains healthy all that is sealed or even well advanced in the l stage may have the bees shaken from it and be distributed among remaining colonies of the apiary. The bees of the diseased col thus become rapidly reduced in numbers, and several of the col themselves may soon be combined, the best queen being select continue egg deposition. Eventually the diseased apiary become the removal of the developing brood and the death of the old reduced to nothing. None of the queens should be saved nor sh any of the adult workers be returned to the healthy apiary.

A combination of the sulphur cure with the last plan mention that of getting rid of the disease through the removal of brood from affected colonies—is really, all in all, the best procedure. a fairly strong colony has been made up by shaking the adult be two or more together and this removed to an isolated locality application of sulphur may be made before any brood has been st It is well, also, to replace the queen with a vigorous one from entirely unrelated to the diseased bees. Should any signs of th ease reappear, constant removal of the brood should be follow mentioned in the preceding paragraph.

Other bacterial diseases, though existing, have developed only locally or have been too limited in the amount of injury inflict require special mention here.

## INSECT AND OTHER ENEMIES.

The bee or wax moth (*Galleria mellonella* Linn.) is regarded by those unfamiliar with modern methods in bee keeping as a very serious enemy to success in this work. It was frequently such when only the common black bee was kept and the old way of managing, or rather of trusting to luck, was followed. But with the better races now introduced and with improved hives and methods, and especially with the care that is now given to have no colonies queenless long at a time, the wax-moth larvæ are no longer regarded with great concern.

Some species of wasps take a little honey at times—more particularly when hives are opened—and they annoy the bees; others capture and eat workers, as do also the large ant-like "cow-killers" (Mutillidæ), and certain predaceous flies (Asilidæ), true bugs (Phymatidæ), and neuropterous and orthopterous insects (Libellulidæ and Mantidæ). The larvæ of certain beetles (Dermestidæ and Tenebrio) feed upon pollen and the cast-off skins of developing larvæ and pupæ, and certain of the Meloid larvæ attach themselves to the bodies of bees as parasites. Ants (Formicidæ) and cockroaches (Blattidæ), which gather above the quilts and between the quilts and the tops of the frames in order to be benefited by the warmth of the cluster of bees, sometimes help themselves to honey, and their presence annoys the bees more or less. Some of the insects here mentioned are only found locally, the predaceous ones being confined mainly to the South, while it may be said that the general welfare of strong colonies is not often materially affected nor the return noticeably reduced through the attacks of any of them.

Spiders, toads, and lizards destroy, in addition to many injurious insects, also some bees, and should be tolerated in the vegetable garden rather than in the apiary.

Swallows, kingbirds or bee martins, mice, skunks, and bears only occasionally commit depredations in the apiary.

Properly constructed hives enable the bees to limit in a great measure the injury which these various enemies might inflict, and the avoidance of overswarming, with care to insure the constant presence of a prolific queen and a supply of food suited to the needs of the colony at the time, will keep it populous and therefore in shape to repel attacks or to make good most of the unavoidable losses.

## ROBBER BEES.

Robbing is sometimes a more serious matter, although it very rarely happens that a little careful attention just at the right time on the part of the bee keeper would not avoid all serious trouble on this score. When bees find nothing to gather during weather when they can still fly out they are easily tempted to appropriate the stores of weaker colonies. Exposure of combs of honey at such times may even occasion a combined attack upon a good colony otherwise quite a care of itself. It is then that the greatest destruction ensues, for such a colony will defend itself vigorously, and a pitched battle, with perhaps fifty or sixty thousand Amazons on either side, leaves the ground literally strewn with dead and dying.

If the invaders conquer, every drop of honey is taken from the few vanquished that are likely to be still alive; and in turn the despoilers invariably fight among themselves as to the possession of the booty. When the robbing takes place during the absence of the owner, the condition of the robbed colony may not attract immediate attention, and during warm weather moth larvæ gain full possession of the combs within a few days. When this condition is observed, the whole damage is very likely to be attributed to the moth larvæ. Colonies that have been left queenless for some time, and those weakened by disease or by overswarming, are especial marks for such attacks. Of course these defects should be remedied whenever observed, but meanwhile, if legitimate field work is likely to be interrupted, every colony should be assisted in protecting itself against assault by having its hive made secure and the entrance such a narrow pass as to enable a few workers to repel attack there.

Should robbers get well started before being observed, the entrance of the hive should be narrowed at once, and wet grass or weeds may be thrown loosely over it, or a pane of glass may be stood against the front of the hive in a slanting manner to confuse the intruders. In extreme cases the attacked colonies may be removed to a cellar for a few days, plenty of ventilation being given during confinement, and a new location, apart from other colonies, selected, on which they are to be placed just at nightfall; or, instead of putting them in the cellar, they may be taken a mile or more away and returned only when the danger has passed. With these precautions, little loss is to be feared on this score.

In general, the intelligent owner who gives careful attention to certain important points in bee management finds that he very rarely has disease to contend with, and that the reduction of profits through the depredations of bee enemies is not, in most parts of the Union, a serious discouragement. Altogether it seems to the writer that the risks in these directions are even less in bee keeping than those usually met in the keeping of other animals, which, like bees, are legitimately made to contribute to the wealth of the individual and of the nation.

## LEGISLATION AFFECTING APIARIAN INTERESTS.

Many States have in recent years passed laws having for their purpose the eradication or suppression of contagious diseases among bees. State and county inspectors have been appointed under these laws, whose duty it is to go about and ascertain where diseased colonies of bees are located, and recommend the treatment to be given, or in some cases to carry out this treatment, even to the complete destruction of

nies or apiaries where the virulence of the attack seems to war-
it. Where these laws have been conscientiously and energeti-
executed, much has been accomplished toward freeing the apia-
of the given State from disease.

ome States have passed laws making it a misdemeanor to spray
t trees during the time of blossoming, since thereby bees are
oned, and besides the injury to the apiarist the pollination of the
t blossoms is seriously interfered with.

aws against the sale of adulterated goods as genuine, known com-
ly as pure-food laws, are in operation in some of the States, and
re bee inspectors or bee keepers have taken the pains to have
e laws applied to the marketing of honey, a check has been put
n the selling of adulterated honey in the liquid form, which has
practiced to a greater or less extent and still occurs in some of
ity markets.

general, the rights of bee keepers to own and cultivate bees, either
in the limits of cities or on farms adjoining those devoted to graz-
and general stock raising, are becoming more clearly defined
ugh decisions of supreme and county courts. In this connection the
k of the National Bee-Keepers' Association should receive mention.
his organization is in no sense a trades union, but has for its purpose
defense of its members against unjust attacks upon their legal
its, the suppression, in so far as possible, of the sale of adulterated
ey, the securing of legislation for the protection of its members
favorable to the general advance of the industry, as well as the
emination among its members of advanced ideas in bee manage-
nt and information regarding the marketing of apiarian products.
membership fee of one dollar per annum entitles every honey
ducer to membership and participation in all of the benefits
merated, as well as to the published report of the annual conven-
held by the association. The membership numbers nearly 2,000
he present time, and the influence of this large body of intelligent
masters is already being appreciably felt in the general advance
he industry in this country.

## JOURNALS TREATING OF APICULTURE.

s a matter of general information, the following list of journals
ting to apiculture is given. It comprises all those published in
country at the present time.

e American Bee Journal, Chicago, Ill.
eanings in Bee Culture, Medina, Ohio.
e Bee Keepers' Review, Flint, Mich.
e American Bee Keeper, Falconer, N. Y.
e Progressive Bee Keeper, Higginsville, Mo.
estern Bee Journal, Kingsburg, Cal.
e Rural Bee Keeper, River Falls, Wis.

## FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number and title of each. Copies will be sent to any address on application to any Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. The missing numbers have been discontinued, being superseded by later bulletins:

No. 16. Leguminous Plants. No. 22. The Feeding of Farm Animals. No. 24. Hog Cholera and Swine Plague. No. 25. Peanuts: Culture and Uses. No. 27. Flax for Seed and Fiber. No. 28. Weeds: And How to Kill Them. No. 29. Souring and Other Changes in Milk. No. 30. Grape Diseases on the Pacific Coast. No. 31. Alfalfa, or Lucern. No. 32. Silos and Silage. No. 33. Peach Growing for Market. No. 34. Meats: Composition and Cooking. No. 35. Potato Culture. No. 36. Cotton Seed and Its Products. No. 37. Kafir Corn: Culture and Uses. No. 38. Spraying for Fruit Diseases. No. 39. Onion Culture. No. 41. Fowls: Care and Feeding. No. 42. Facts About Milk. No. 43. Sewage Disposal on the Farm. No. 44. Commercial Fertilizers. No. 45. Insects Injurious to Stored Grain. No. 46. Irrigation in Humid Climates. No. 47. Insects Affecting the Cotton Plant. No. 48. The Manuring of Cotton. No. 49. Sheep Feeding. No. 50. Sorghum as a Forage Crop. No. 51. Standard Varieties of Chickens. No. 52. The Sugar Beet. No. 54. Some Common Birds. No. 55. The Dairy Herd. No. 56. Experiment Station Work—I. No. 57. Butter Making on the Farm. No. 58. The Soy Bean as a Forage Crop. No. 59. Bee Keeping. No. 60. Methods of Curing Tobacco. No. 61. Asparagus Culture. No. 62. Marketing Farm Produce. No. 63. Care of Milk on the Farm. No. 64. Ducks and Geese. No. 65. Experiment Station Work—II. No. 66. Meadows and Pastures. No. 68. The Black Rot of the Cabbage. No. 69. Experiment Station Work—III. No. 70. Insect Enemies of the Grape. No. 71. Essentials in Beef Production. No. 72. Cattle Ranges of the Southwest. No. 73. Experiment Station Work—IV. No. 74. Milk as Food. No. 75. The Grain Smuts. No. 77. The Liming of Soils. No. 78. Experiment Station Work—V. No. 79. Experiment Station Work—VI. No. 80. The Peach Twig-borer. No. 81. Corn Culture in the South. No. 82. The Culture of Tobacco. No. 83. Tobacco Soils. No. 84. Experiment Station Work—VII. No. 85. Fish as Food. No. 86. Thirty Poisonous Plants. No. 87. Experiment Station Work—VIII. No. 88. Alkali Lands. No. 89. Cowpeas. No. 91. Potato Diseases and Treatment. No. 92. Experiment Station Work—IX. No. 93. Sugar as Food. No. 94. The Vegetable Garden. No. 95. Good Roads for Farmers. No. 96. Raising Sheep for Mutton. No. 97. Experiment Station Work—X. No. 98. Suggestions to Southern Farmers. No. 99. Insect Enemies of Shade Trees. No. 100. Hog Raising in the South. No. 101. Millets. No. 102. Southern Forage Plants. No. 103. Experiment Station Work—XI. No. 104. Notes on Frost. No. 105. Experiment Station Work—XII. No. 106. Breeds of Dairy Cattle. No. 107. Experiment Station Work—XIII. No. 108. Saltbushes. No. 109. Farmers' Reading Courses. No. 110. Rice Culture in the United States. No. 111. Farmers' Interest in Good Seed. No. 112. Bread and Bread Making. No. 113. The Apple and How to Grow It. No. 114. Experiment Station Work—XIV. No. 115. Hop Culture in California. No. 116. Irrigation in Fruit Growing. No. 118. Grape Growing in the South. No. 119. Experiment Station Work—XV. No. 120. Insects Affecting Tobacco. No. 121. Beans, Peas, and other Legumes as Food. No. 122. Experiment Station Work—XVI. No. 123. Red Clover Seed: Information for Purchasers. No. 124. Experiment Station Work—XVII. No. 125. Protection of Food Products from Injurious Temperatures. No. 126. Practical Suggestions for Farm Buildings. No. 127. Important Insecticides. No. 128. Eggs and Their Uses as Food. No. 129. Sweet Potatoes. No. 131. Household Tests for Detection of Oleomargarine and Renovated Butter. No. 132. Insect Enemies of Growing Wheat. No. 133. Experiment Station Work—XVIII. No. 134. Tree Planting in Rural School Grounds. No. 135. Sorghum Sirup Manufacture. No. 136. Earth Roads. No. 137. The Angora Goat. No. 138. Irrigation in Field and Garden. No. 139. Emmer: A Grain for the Semiarid Regions. No. 140. Pineapple Growing. No. 141. Poultry Raising on the Farm. No. 142. Principles of Nutrition and Nutritive Value of Food. No. 143. The Conformation of Beef and Dairy Cattle. No. 144. Experiment Station Work—XIX. No. 145. Carbon Bisulphid as an Insecticide. No. 146. Insecticides and Fungicides. No. 147. Winter Forage Crops for the South. No. 148. Celery Culture. No. 149. Experiment Station Work—XX. No. 150. Clearing New Land. No. 151. Dairying in the South. No. 152. Scabies in Cattle. No. 153. Orchard Enemies in the Pacific Northwest. No. 154. The Home Fruit Garden: Preparation and Care. No. 155. How Insects Affect Health in Rural Districts. No. 156. The Home Vineyard. No. 157. The Propagation of Plants. No. 158. How to Build Small Irrigation Ditches. No. 159. Scab in Sheep. No. 161. Practical Suggestions for Fruit Growers. No. 162. Experiment Station Work—XXI. No. 164. Rape as a Forage Crop. No. 165. Culture of the Silkworm. No. 166. Cheese Making on the Farm. No. 167. Cassava. No. 168. Pearl Millet. No. 169. Experiment Station Work—XXII. No. 170. Principles of Horse Feeding. No. 171. The Control of the Codling Moth. No. 172. Scale Insects and Mites on Citrus Trees. No. 173. Primer of Forestry. No. 174. Broom Corn. No. 175. Home Manufacture and Use of Unfermented Grape Juice. No. 176. Cranberry Culture. No. 177. Squab Raising. No. 178. Insects Injurious in Cranberry Culture. No. 179. Horseshoeing. No. 181. Pruning. No. 182. Poultry as Food. No. 183. Meat on the Farm.—Butchering, Curing, etc. No. 184. Marketing Live Stock. No. 185. Beautifying the Home Grounds. No. 186. Experiment Station Work—XXIII. No. 187. Drainage of Farm Lands. No. 188. Weeds Used in Medicine. No. 189. Information Concerning the Mexican Cotton Boll Weevil. No. 190. Experiment Station Work—XXIV. No. 191. The Cotton Bollworm—1903. No. 192. Barnyard Manure. No. 193. Experiment Station Work—XXV. No. 194. Alfalfa Seed. No. 195. Annual Flowering Plants. No. 196. Usefulness of the American Toad. No. 197. Importation of Game Birds and Eggs for Propagation. No. 198. Strawberries. No. 199. Corn Growing. No. 200. Turkeys. No. 201. Cream Separator on Western Farms. No. 202. Experiment Station Work—XXVI. No. 203. Canned Fruits, Preserves, and Jellies. No. 204. The Cultivation of Mushrooms. No. 205. Pig Management. No. 206. Milk Fever and Its Treatment. No. 207. Game Laws for 1904. No. 208. Varieties of Fruits Recommended for Planting. No. 209. Controlling the Boll Weevil in Cotton Seed and at Ginneries. No. 210. Experiment Station Work—XXVII. No. 211. The Use of Paris Green in Controlling the Cotton Boll Weevil. No. 212. The Cotton Bollworm—1904. No. 213. Raspberries. No. 214. Beneficial Bacteria for Leguminous Crops. No. 215. Alfalfa in the Eastern States. No. 216. Control of the Cotton Boll Weevil. No. 217. Essential Steps in Securing an Early Crop of Cotton. No. 218. The School Garden. No. 219. Lessons Taught by the Grain Rust Epidemic of 1904. No. 220. Tomatoes. No. 221. Fungous Diseases of the Cranberry.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 74.

# ILK AS FOOD.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.

WASHINGTON:
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1898.

# LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
*Washington, D. C., March 1, 1898.*

SIR: I have the honor to transmit herewith an article on milk as food, prepared in this Office, treating of the nutritive value of milk, and suggesting some of the ways in which it may be combined with other food materials to make well-balanced and economical dietaries. In the preparation of this article the results of the investigations on the nutritive value of foods, including milk, made under direction of Prof. W. O. Atwater, have been utilized, as well as information gathered from other authoritative sources. I recommend that the article be published as a Farmers' Bulletin.

Respectfully,

A. C. TRUE,
*Director.*

Hon. JAMES WILSON,
*Secretary of Agriculture.*

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# MILK AS FOOD.

## INTRODUCTION.

A quart of milk contains about the same amount of nutriment as ee-quarters of a pound of beef, namely, about 4 ounces. Six ounces bread would likewise supply not far from 4 ounces of nutritive sub- nces. To put it in another way, about one-eighth of the whole ght of the milk, one-third of the beef, and two-thirds of the bread sist of actually nutritive ingredients. The other seven-eighths of milk and one-third of the bread are water, while the two-thirds the meat which is not actual nutriment is mainly water, but consists part of bone.

But while the quart, or 2 pounds, of milk, the 12 ounces of beef, and 6 ounces of bread all supply like amounts of nutriment, the nutri- e values are not exactly the same; in other words, they would not equally useful for food. Either the milk or the bread eaten alone uld make a better balanced food for man than the meat, because it tains the different kinds of nutritive ingredients, or nutrients, in portions more nearly adapted to supply the wants of the body than the case with the nutrients of the meat.

Milk contains all of the ingredients needed for nourishment; that is, furnishes the materials which build up the body and keep it in repair, d also those which supply it with fuel to keep it warm and to furnish e animal machine with the power needed to do its work.

The composition of milk and other food materials, the kinds and ounts of different ingredients they contain, are found by analysis the chemical laboratory. But (since analysis is a separation into nstituent parts) a rough analysis of milk is made in the dairy and in e kitchen. When milk stands the cream rises. This cream consists minute particles of fat, surrounded by casein and other substances. e cream is put in the churn and shaken, and the globules of fat ther together as butter. This separation of the butter fat is a partial alysis of the milk. When rennet is added to milk it is curdled. The ment of the rennet causes the casein to coagulate, forming the curd. is is put in the cheese press, the liquid is pressed out, and the curd changed to cheese, which contains the casein and with it fat and other aterials which were in the milk and were entangled or inclosed in the coagulated casein. The whey from which the curd has been separated contains a kind of sugar, which can in its turn be separated from the fluid, and is prepared commercially and sold as milk sugar. After the sugar has been removed there still remains in the milk considerable amounts of mineral compounds.

If at the outset the milk had been heated, the water might have been evaporated and the casein, fat, sugar, mineral salts, and other materials would have remained as the milk solids. These together make up the nutrients of the milk.

When milk is used for food the casein and allied compounds serve the body for building and repair, and are also used for fuel. The fat and sugar are the chief fuel ingredients. The mineral compounds aid in forming tissue, and have other uses as well, but they are needed only in small quantities.

The value of milk for nourishment is not as well understood as it should be. Many people think of it as a beverage, rather than a food. To understand its nutritive value, and how it compares with other food materials in this regard, we must consider, briefly, the nature, composition, and uses of food materials.

## FOOD AND ITS FUNCTIONS.

Food is that which, when taken into the body, builds up its tissues and keeps them in repair or which is consumed in the body to yield force and heat. It is used to form the tissues and fluids of the body, such as muscle, blood, bone, and brain, to repair their waste, and, if in excess of the daily requirements, it may be stored in the body for future consumption. The material thus stored is principally fat. When food or body tissue is consumed in the system, the energy which lay latent therein becomes active and manifests itself in the force or heat required for the various bodily uses.

The best foods are those which perform their function in the most thorough and complete manner; that is, with as little waste as possible and with the best physiological results. We usually judge of the value of a food by several different standards. Thus, it must be digestible and palatable, furnish the ingredients needed by the system in proper amounts, and be reasonably cheap.

Some food materials contain inedible portions, such as bone, shell, skin, etc. The edible portion of food materials consists of water and of some or all of the four classes of nutrients—protein, fat, carbohydrates, and mineral matter. The protein compounds are those which contain nitrogen, and are necessary for the repair of old and the building of new tissue. When in excess of what is thus needed they may be simply burned to produce the required force. Body tissue when broken down also yields energy. Familiar examples of protein are lean of meat and fish, white of egg, casein of milk (and cheese), and gluten of wheat. The fats and carbohydrates are used as a source of energy or force. Fat is found in fat meats, lard, fat of milk (butter), and oils—such as olive oil. Starches, sugars, and woody fiber or cellulose form the bulk of the carbohydrates. The protein, fats, and carbohydrates are all organic substances; that is, they can be burned with the formation of various gases, chiefly carbon dioxid and water, leaving no solid residue. The mineral matters will not burn and are left behind when organic matter is ignited.

The most familiar mineral compounds in food are perhaps calcium phosphate (bone phosphate, or phosphate of lime) and sodium chlorid (common salt).

In order to have some measure for expressing the amount of heat that a given substance is capable of yielding, the calorie is taken as a unit. Roughly speaking, this is the amount of heat required to raise the temperature of 1 pound of water 4 degrees Fahrenheit. One pound of sugar or starch would, if burned and all the heat utilized, raise 1,860 pounds of water 4 degrees in temperature; or it would raise 5 gallons of water from the freezing point to the boiling point, but would not cause it to boil.

The fuel value of a pound of protein as it is ordinarily burned in the body is very nearly the same as that of a pound of carbohydrates, but fats have a fuel value 2¼ times that of protein and carbohydrates, or 4,220 calories per pound.

## COMPOSITION OF MILK.

The chief bulk of milk is, of course, made up of water, the amount of which may vary even in ordinary unadulterated milk from 90 per cent in a very poor product to 84 per cent in an unusually rich milk. The corresponding solid matter, or "total solids," varies from 10 per cent to 16 per cent. This solid matter, or "total nutrients," is made up of protein, fats, carbohydrates, and mineral matter. The proportion of these vary within certain limits; but, roughly speaking, one twentieth of the total solids are mineral substances, one-fourth protein, three-tenths fat, and four-tenths carbohydrates.

**The protein compounds of milk.**—The principal nitrogenous compound of milk is casein. This, when the milk is drawn from the cow, is in a form which is called caseinogen, but undergoes changes which bring it into the form of casein. For convenience it is here referred to in all its forms as casein. In chemical composition the casein differs from the other protein compounds of milk in that it contains both phosphorus and sulphur. Besides the casein there is a certain amount of albumin present, called lact-albumin, or albumin of milk. This is more or less similar to the albumin which occurs in blood and in white of egg. The quantity of albumin is very much smaller than that of the casein, being on the average about one-seventh of the total protein.

There are other nitrogenous substances occurring in milk, but in insignificant quantities. The total protein of milk should not vary in any great degree. It will average not far from 3.3 per cent of the whole milk, or about 25 per cent of the total solids.

**The fats of milk.**—The fat of milk is commercially the most important of its constituents, since it is the source of butter and enters largely into the composition of cheese. Chemically speaking, the fat of milk, or butter fat, as it is more often called, consists of several different fats. The chief of these are the same fats that make up the bulk of fat meat (tallow, lard, etc.), as well as many vegetable fats. They are called stearin, palmitin, and olein. Besides these three fats there are others in smaller amounts, but of considerable importance, since it is to them that the flavor and aroma of the butter is due. The amount of fat in milk varies widely, the amount in normal milk depending upon various conditions, some of which are mentioned beyond. The amount of fat should not fall below 3 per cent, and, except in unusually rich milk, will not exceed 5 per cent. Good unadulterated milk from a herd of well-fed cows should average not far from 4 per cent of butter fat, or about 31 per cent of the total solids of the milk.

**The carbohydrates of milk.**—The chief compound of this class which occurs in milk is lactose, or sugar of milk. Milk sugar is similar in chemical composition to cane sugar, but is not nearly as sweet. It is largely used by physicians and pharmacists as the basis of powders and pills. In amount it ranges from 4 to 6 per cent, but on the average may be said to be 5 per cent, of the milk, or about 38 per cent of the total solids.

There is a considerable variation in the composition of the milk of different animals. The richest milk appears to come from the dog, the poorest from the horse. Human milk is richer in sugar and poorer in protein than cow's milk, but the fuel value is about the same. These facts are brought out in the following table:

*Comparative composition of various kinds of milk.*[1]

| Kind of milk. | Water. | Total solids. | Total solids. | | | | | | Fuel value per pound. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Protein. | | | Fat. | Carbohydrates (milk sugar). | Mineral matters (ash). | |
| | | | Casein. | Albumin. | Total protein. | | | | |
| | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Calories.* |
| Woman | 87.4 | 12.6 | 1.0 | 1.3 | 2.3 | 3.8 | 6.2 | 0.3 | [illegible] |
| Cow | 87.2 | 12.8 | 3.0 | .5 | 3.5 | 3.7 | 4.9 | .7 | [illegible] |
| Dog | 75.4 | 24.6 | 6.1 | 5.1 | 11.2 | 9.6 | 3.1 | .7 | [illegible] |
| Ewe | 80.8 | 19.2 | 5.0 | 1.5 | 6.5 | 6.9 | 4.9 | .9 | [illegible] |
| Buffalo | 81.4 | 18.6 | 5.8 | .3 | 6.1 | 7.5 | 4.1 | .9 | [illegible] |
| Cat | 82.1 | 17.9 | 3.1 | 6.0 | 9.1 | 3.3 | 4.9 | .6 | [illegible] |
| Goat | 85.7 | 14.3 | 3.2 | 1.1 | 4.3 | 4.8 | 4.4 | .8 | [illegible] |
| Llama | 86.5 | 13.5 | 3.0 | .9 | 3.9 | 3.2 | 5.6 | .8 | [illegible] |
| Ass | 89.6 | 10.4 | .7 | 1.6 | 2.3 | 1.6 | 6.0 | .5 | [illegible] |
| Mare | 91.5 | 8.5 | 1.2 | .1 | 1.3 | 1.2 | 5.7 | .3 | [illegible] |

[1] König, Chemie der menschlichen Nahrungs- und Genussmittel, 3d ed., I, pp. 267-362.

## CHARACTERISTICS AND PROPERTIES OF MILK.

he color and opaqueness of milk are due mainly to globules of fat,
ch are very minute and almost numberless. These are held in sus-
sion in the liquid in the form of an emulsion; but, since they are
ter than water, after the milk has stood for some time they gradu-
rise to the surface, and thus accumulating form the cream. The
n of the separator is on the same principle, only in this case the
ier portion of milk, i. e., the water, casein, and sugar, are thrown
r from the center as possible by the rapidly rotating machine, and
ighter cream, being thus forced to the center, can be drawn off.
hen milk has stood for some time, the milk sugar undergoes decom-
tion, whereby lactic acid is formed and the milk becomes sour.
mpanying this souring of milk, there is a change in its consistency
it becomes thick or curdled. The same change can be brought
t by the addition of an acid, vinegar for example. If milk thus
led is neutralized with some alkali, such as limewater or soda, the
is redissolved. Milk is also curdled or coagulated by rennet, and
urd thus produced is utilized in the manufacture of cheese. This
, unlike that of ordinary sour milk, is not dissolved by the addition
mewater or soda.

scum forms upon the surface of milk when it is boiled. This is
ably due to the coagulation by heat of the protein of the milk,
fly its albumin, but perhaps to a slight extent its casein also.
ilk is slightly heavier than water, its specific gravity ranging from
9 to 1.034 at 60° F. This means that while a quart of water weighs
unds 1⅓ ounces, a quart of milk weighs from 1.029 to 1.034 times as
h, or not far from 2 pounds 2½ ounces. The specific gravity depends
n the proportion of water and other substances. Since the fat is
ter than water, the richer the milk is in butter fat the lower its
ific gravity, provided, of course, that the other solids are not
eased proportionally. It follows, also, that the removal of the fat
eases the specific gravity, so that skim milk has a specific gravity
rom 1.033 to 1.037. On the other hand, the addition of water to
med milk brings down the specific gravity.

## VARIATIONS IN MILK.

xcepting meats, there is probably no one article of food which is
le to so wide a variation in its percentage composition as the milk
plied the consumer. The variations are so great, in fact, as to make
tirely possible that one man may pay nearly twice as much as his
hbor for the same amount of nutrients when both buy it at the
e price per quart. The causes of such variations are quite numerous
need be touched upon but briefly. The variation in composition of
milk is due in a large degree to the breed or individuality of the

cow, to the methods of feeding and handling, and the length of time since calving.

With regard to this subject Professor Voorhees[1] says:

> The influence of breed is very marked, so much so that dairy breeds are classified into milk and butter breeds—that is, those which give a large quantity of poorer quality, and those which give a smaller quantity of a higher quality. * * * With the improvement of the stock by the introduction of recognized butter-producing breeds of cows the quality of the product also materially improves.

In general young cows produce richer milk than old ones, though much depends upon the health and vigor of the animal. A well-fed cow gives more and better milk than one which is poorly fed, but the relative proportions of fat, casein, and sugar do not appear to be greatly influenced by the composition of the food. The average cow of a given breed possesses certain capabilities for producing milk, but does not reach her normal capacity of milk production unless she is well fed. When once she has a sufficient and well-balanced ration, neither the composition nor the amount of the milk yield seems to be greatly improved by either increasing the ration or changing the proportion of its ingredients.

The milk flow of a given cow is usually largest soon after calving; as the period of lactation increases, the flow gradually falls off, and, as a rule, the milk grows richer, i. e., the proportion of solids increases. The proportion of fat to the other solids in the milk of a given cow varies from day to day and from milking to milking.

Another cause of variation in milk is found in the temptation of unprincipled milkmen to adulterate their product. The chief methods of adulteration are (1) the addition of water, (2) the removal of a portion of the fat, either with or without the addition of water, and (3) the addition of preservatives. The two former methods result in a greater or less diminution of the food value, depending upon the extent of adulteration. The latter method does not detract from the total nutrients in the milk but it adds substances which, while not active poisons, may, when taken in the milk regularly in small amounts, produce deleterious results. The specific gravity of the milk is sometimes used as a test of its purity, but since removing part of its fat in form of cream raises and adding water lowers the specific gravity, one form of adulteration may counteract and cover up the other, and thus render this test alone unreliable.

The flavor of milk is frequently affected by the food eaten by the cow. It is a familiar fact that turnips when fed to cows give a peculiar taste or flavor to the milk.

The milk of diseased cows may be very abnormal in composition and may be the means of conveying disease. It is well understood that milk can act as a carrier of infection, and it is therefore of the greatest importance that especial care be taken in the dairy to insure the cleanliness of milk and to render its exposure to any germs of infectious diseases or to impure air of any sort impossible. It should be possible in all large cities, as well as in the smaller cities and country towns, to obtain some assurance that the milk received comes from healthy animals and receives proper care and attention after being drawn from the cow. This assurance should be obtained either by the public authorities, by the employment of honest reputable dealers, or by personal inspection and examination. The subject of the control and examination of the milk supply is treated at further length in Farmers' Bulletin No. 42 of this Department.[1]

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[1] U. S. Dept. Agr., Office of Experiment Stations Bul. 35.

## NUTRITIVE VALUE OF MILK.

Milk is peculiarly adapted for use as a food by man for several reasons. It contains all of the four classes of nutrients—protein, fats, carbohydrates, and mineral matter in more nearly the proper proportion to serve as a complete food than any other food material, although no one substance can furnish a complete food for an adult for reasons referred to beyond. It is in a form well adapted for varied uses either alone or more especially in combination with other food substances and in the preparation of various dishes for the table. Its use is already considered indispensable in many such cases and it might profitably be used in many more. At the price ordinarily paid for milk in our large cities it is a food of reasonable cheapness, and at the prices prevailing in small cities and country towns it is an economical food. (See p. 20.)

## DIGESTIBILITY OF MILK.

In general, milk ranks as a very digestible food, but when we come to speak more definitely as to its digestibility there are difficulties of two kinds. One of these has to do with what is understood by the term digestibility; the other has to do with the differences of different persons in respect to their powers of digestion.

By digestibility of food several things are, or may be, meant. One is the proportion of a given food material or of each of its several constituents which an ordinary person may digest. Another is the ease with which it is digested or the time required by the process. As the word is ordinarily used, however, it includes still another consideration, namely, whether the food material does or does not agree with the user.

**Proportions of nutrients digested.**—"We live not upon what we eat, but upon what we digest." In other words, the value of food for nutriment depends not only upon how much of the nutrients it contains, but upon how much of these the body actually digests and uses for its support. To put it in another way, the most important factor of digestibility, so far as the nutritive value of food is concerned, is found in the proportions of its different nutrients which can actually be digested by healthy persons and used for nourishment. Considerable experimenting has been done upon this subject. While it is found that different people vary in the amounts which they can digest from the same food, the differences are not as great as might be supposed. The results, in so far as they apply to milk alone, and in comparison with other food materials, may be briefly summarized as follows: The protein of milk, especially when it is used with other food materials, is quite readily and completely digested. In this respect it is like the protein of ordinary meats and fish. The protein of vegetable foods is much less completely digested. Thus, in potatoes and whole wheat and rye flour it may sometimes happen that as much as one-fourth of the protein may escape digestion and thus be useless for nourishment. From one-sixth to one-tenth of the protein of wheat flour, corn meal, beans, and peas may in like manner be assumed to escape digestion, or rather to leave the body without being used for nutriment. These estimates assume that the materials are cooked and eaten in the usual way. Under the same circumstances, from nine-tenths to the whole of the protein of milk, meats, and fish are assumed to be digested. The digestibility of the fats is likewise variable. Sometimes a large part of the fat of the food fails of digestion. In general it may be assumed that about 5 per cent of the fat of milk, meat, eggs, butter, and lard, and a considerably larger proportion of the fats of some vegetable foods, will usually escape digestion. When, however, the diet contains a very large amount of fat—for instance, when it consists largely of fat meat—the digestion is less complete. One way in which the fat of ordinary foods is digested is by being made into an emulsion in the intestine. The fat of milk is an extremely fine emulsion and is thus in a sense "predigested" or in a partly digested form before it is taken into the stomach. This may help to explain why it is so easily digested.

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[1] See also U. S. Dept. Agr., Bureau of Animal Ind

The carbohydrates, which make up a large part of vegetable foods, are in general very digestible. Cane sugar is believed to be completely digested, and this is assumed to be the case with the sugar of milk.

The animal foods have in general the advantage of the vegetable foods in digestibility in that they contain more protein and their protein is more digestible. Milk ranks among the most digestible of the animal foods in respect to all its ingredients.

**The process of digestion.**—When milk is taken into the stomach, it is speedily curdled by the action of the pepsin and acid of the gastric juice. When milk is eaten alone or in large quantities, the casein gathers in large lumps, which may be difficult of digestion by some. This is particularly the case with infants and with adults whose digestion is weak, and is one of the reasons why milk should be used with other foods and not taken in large quantities alone. Human milk differs from cow's milk in the way in which it curdles when taken into the stomach. The casein of the former is not precipitated in such large lumps, but is more flocculent, and is thus more easily digested and does not cause irritation. This explains one reason why woman's milk is believed to be better than cow's milk for infants. The small flocculent particles of casein of the former are digested more easily and do not produce the bad effects which sometimes come from the curdling of the

r. When cow's milk has been boiled before it is taken into the nch, it is likely to be precipitated in more flocculent form. It is sup- l by some chemists that when milk is boiled part of the phosphate ne is precipitated, and that when the latter is thus removed the is more flocculent. It is also believed that lime tends to prevent the ing of the casein in lumps, doing so both by neutralizing the acid lso by its intrinsic power of retarding coagulation. For this rea- little limewater is frequently added to milk that is to be fed to ts. For the same reason some adults of delicate digestion who hat fresh milk does not agree with them can use it with impunity as been boiled or if limewater is added.

the processes of digestion and assimilation the different ingredi- of the food undergo a great variety of chemical changes, and some e compounds that are formed may be at times harmful in one way other. Indeed, some of the compounds produced from the food in ody may be actually poisonous. Different persons are differently tituted with respect to these chemical changes which the food rgoes and the effects produced, so that it may be literally true "one man's meat is another man's poison." This is the case with . While for most persons it is a very wholesome, digestible, and tious food, there are those who are made ill by drinking it. In nanner some people are made seriously ill by eating eggs, fruits, her food materials.

**gestion v. utilization of food.**—One important thing to remember is the food which we digest is not always utilized to the best advan- Different people differ greatly in this respect. One man may be to do a large amount of work and another very little, when both the same diet and digest the same amount of nutrients from it. person will grow fat upon an amount of digested material with another will hardly hold his own. The getting of the most good food is not so much a matter of digestion as of making use of is digested.

persons are alike in that they must have protein for the building epair of the bodily machine, and fuel ingredients for warmth and . But they differ widely in the amounts and proportions they ire, even among those in good health.

r persons in good health and with good digestion there are two rtant rules to be observed in the regulation of the diet. The first choose the things which "agree" with them, and to avoid those h they can not digest and assimilate without harm. The second is se such kinds and amounts of food as will supply all the nutrients body needs and at the same time avoid burdening it with super- us material to be disposed of at the cost of health and strength.

r guidance in this selection nature provides us with instinct, taste, experience. Physiological chemistry adds to these the knowledge— new and far from adequate—of the composition of food and the of nutrition. In our actual practice of eating we are apt to be influenced too much by taste—that is, by the dictates of the palate; we are prone to let natural instinct be overruled by acquired appetite, and we neglect the teachings of experience. We need to observe our diet and its effects more carefully, and regulate appetite by reason. In doing this we may be greatly aided by the knowledge of what our food contains and how it serves its purpose in nutrition.

**Effects of cooking.**—Cooking changes the texture of a food material and affects its digestibility to a greater or less extent. In general it increases the digestibility of the vegetable food materials. This is true more especially of boiling or steaming. During the process of cooking, the cells of vegetables burst and the tissue of meat becomes softened and loosened, thus facilitating digestion by exposing them more fully to the action of the digestive juices.

In the case of milk the experience of different persons with cooked and uncooked milk is quite varied, and the results of the experiments upon the subject are conflicting. The more common experience seems to indicate that cooking or heating the milk makes the proteids somewhat more difficult for most persons to digest, but there are exceptions to this rule, if it be a rule. For instance, as above stated, there are persons who can not take fresh milk with comfort, but with whom boiled milk agrees very well.

## SKIM MILK.

Even after average milk is skimmed it still contains nearly 10 per cent (one-tenth of its weight) of solids or nutritive ingredients. The amount of fat left in skim milk varies greatly with the method of creaming. Ordinary open shallow pan setting leaves anywhere from one tenth to one-quarter of the original fat of the milk in the skim milk. Deep cold setting removes the fat much more completely, so that Cooley skim milk has from a trace to three-tenths or four-tenths of one per cent of fat. Separator skim milk has usually less fat than that from deep cold setting. It is not far out of the way to say that a pound of skim milk contains 0.034 pound protein and has a fuel value of 170 calories or a little more protein than the same weight of whole milk and about one-half the fuel value.

At first thought it may be difficult to understand how removing the fat increases the amount of protein, but the explanation is simple. One pound of whole milk contains on the average 3.3 per cent or 0.033 pound of protein and 4 per cent or 0.04 pound of fat. If all the fat is removed, there will be left 0.96 pound of skim milk containing 0.033 pound of protein, or about 3.5 per cent, so that 1 pound of skim milk would contain about 0.035 pound of protein. For the same reason there is a slightly larger proportion of milk sugar in skim milk than in whole milk.

The value of skim milk as food is not generally appreciated. Taken by itself it is rather "thin" and, to use a common expression, "does not stay by." The reason for this is simple: One has to drink a large *quantity to* get the needed nourishment, and, further, it is so readily disosed of that it does not satisfy the sense of hunger. But when taken ith bread or used in cooking, it forms a very nutritious addition to he food. A pound of lean beef (round steak, for example) contains bout 0.18 pound of protein and has a fuel value of 870 calories. Two nd a half quarts, or 5 pounds, of skim milk will furnish nearly the same mount of protein and have about the same fuel value as the pound of ound steak. Two quarts of skim milk has a greater nutritive value han a quart of oysters; the skim milk has 0.14 pound of protein and a uel value of 680 calories, while the oysters contains only 0.12 pound of protein and have a fuel value of 470 calories. The nutriment in the form of oysters would cost from 30 to 50 cents, while the 2 quarts of skim milk would have a market value of from 4 to 6 cents and a value on the farm of from 2 to 4 cents. An oyster stew made of one part oysters and two parts skim milk would owe its nutriment more to the milk than to the oysters. Bread made with skim milk would contain more protein than when made with water. A lunch or meal of bread and skim milk is very nutritious, as the following computation shows:

*Composition and cost of a lunch or meal of bread and skim milk.*

| Food materials. | Amount. | Estimated cost. | Protein. | Fuel value. |
|---|---|---|---|---|
| | | *Cents.* | *Pound.* | *Calories.* |
| Bread | 10 oz. | 3 | 0.06 | 755 |
| Skim milk | 1 pt. | 1 | .03 | 170 |
| Total | | 4 | .09 | 925 |

The commonly accepted standard for a man at ordinary muscular work calls for 0.28 pound of protein and a fuel value of 3,500 calories per day, so that the above lunch furnishes very nearly one-third of a day's nutriment and at a cost of but 4 cents. If whole milk were used instead of skim milk, the cost would be about 6 cents and the fuel value 1,080 calories, while the protein would remain the same in amount.

The following lunch, such as might be obtained in a restaurant or lunch room, will serve for the purpose of comparison:

*Estimated cost and nutrients of a restaurant lunch.*

| Food materials. | Amount. | Estimated cost. | Protein. | Fuel value. |
|---|---|---|---|---|
| | *Ounces.* | *Cents.* | *Pound.* | *Calories.* |
| Soup | 8 | | 0.01 | 75 |
| Beef | 2 | | .02 | 275 |
| Potatoes | 2 | | | 100 |
| Turnips | 1 | | | 15 |
| Bread | 4 | | .02 | 300 |
| Butter | ½ | | | 100 |
| Coffee: | | | | |
| Milk | 1 | | | 20 |
| Sugar | ½ | | | 55 |
| Total | | 15 to 20 | .05 | 940 |

It will thus be seen that the 15-cent lunch containing nine different food materials did not have any greater nutritive [illegible] lunch of bread and skim milk.

heat and muscular power. When these facts are fully
milk will doubtless be more wisely utilized. The ways i
cook can utilize skim milk in cooking are almost endles
thus added to the daily ration is of the utmost importa

## CREAM.

When the globules of fat rise in the milk, they entan
a considerable amount of milk which is removed with t
Cream is thus the butter fat of the milk with some pro
hydrates due to the intermixed milk, and contains on th
four and one-half times the amount of fat contained in
of milk. The amount of protein and of carbohydrate
than in whole milk. The fuel value of a pint of crean
1,425 calories, or about the same as 1½ pounds of bre
bananas, or 4½ pounds of potatoes. Four quarts of wh
not furnish quite as much energy (1,300 calories), but
the protein over six times. It is thus seen that cr
chiefly for its heat-giving properties and that the ski
the valuable protein. When it is considered that
retails at from 12 to 25 cents, and a pound of butter fro
and that the latter is worth two and a half times t
source of energy, it will be seen that cream is no
economical food.

## BUTTERMILK.

Besides skim milk, there is another important by-pr
from the manufacture of butter—namely, buttermilk.
this is used as a beverage to a considerable extent, and th

, leaving the buttermilk. Buttermilk is thus seen to be prac-
e same thing as skim milk, only as a rule it is sour, owing to
n being soured before churning.

## VE VALUE OF MILK AS COMPARED WITH OTHER FOODS.

following table the amount and fuel value of the nutrients in a
whole milk, skim milk, and buttermilk are compared with the
furnished by a pound of some other foods.
pared with the animal foods, it will be noted from this table
contains carbohydrates and has no refuse. In these two
it resembles more nearly many of the vegetable foods, such as
meal, etc. The amount of mineral matter is much the same as in
fresh substances given. There is a larger proportion of water
an in most other food materials, so that a given weight contains
matter or nutrients than most foods. It must be remembered,
that the comparison is here made of a pint of milk with an
ight of the other more condensed food materials without taking
into consideration.

*nutrients in a pound (pint) of milk as compared with a pound of meat, bread, and other food products.*

| materials. | Refuse. | Edible portion. | | | | | |
|---|---|---|---|---|---|---|---|
| | | Water. | Nutrients. | | | | Fuel value. |
| | | | Protein. | Fat. | Carbohydrates. | Mineral matter. | |
| *(1 pint).* | *Pound.* | *Pound.* | *Pound.* | *Pound.* | *Pound.* | *Pound.* | *Calories.* |
| | | 0.87 | 0.03 | 0.04 | 0.05 | 0.01 | 325 |
| .3 per cent fat) | | .90 | .04 | | .05 | .01 | 170 |
| | | .91 | .03 | .01 | .05 | .01 | 165 |
| *aterials (1 pound ach).* | | | | | | | |
| | | .34 | .26 | .34 | .02 | .04 | 1,965 |
| | | .11 | .01 | .85 | | .03 | 3,605 |
| | 0.08 | .61 | .18 | .12 | | .01 | 870 |
| clod | | .69 | .19 | .11 | | .01 | 835 |
| | .13 | .53 | .16 | .17 | | .01 | 1,040 |
| rter | .19 | .50 | .14 | .16 | | .01 | 950 |
| arter | .16 | .51 | .15 | .17 | | .01 | 1,000 |
| | .19 | .43 | .13 | .24 | | .01 | 1,275 |
| | .16 | .44 | .14 | .25 | | .01 | 1,340 |
| | .14 | .35 | .13 | .34 | | .04 | 1,655 |
| | | .07 | .02 | .87 | | .04 | 3,715 |
| | .35 | .48 | .15 | .01 | | .01 | 325 |
| | .30 | .58 | .11 | | | .01 | 205 |
| | .25 | .40 | .16 | | | .19 | 315 |
| lt | .23 | .38 | .17 | .17 | | .10 | 1,050 |
| ds | | .88 | .06 | .02 | .03 | .01 | 235 |
| | | .12 | .11 | .01 | .75 | .01 | 1,645 |
| | | .13 | .09 | .02 | .75 | .01 | 1,655 |
| | | .07 | .16 | .07 | .68 | .02 | 1,860 |
| | | .35 | .10 | .01 | .53 | .01 | 1,205 |
| | | .08 | .11 | .10 | .69 | .02 | 1,895 |
| | | .13 | .22 | .02 | .59 | .04 | 1,500 |
| | .20 | .70 | .01 | | .08 | .01 | 170 |
| | .15 | .67 | .02 | | .15 | .01 | 325 |
| | .30 | .62 | .01 | | .06 | .01 | 135 |
| | .25 | .62 | .01 | | .12 | | 255 |

If we wish to compare the food values of the actually nutri ingredients (the dry matter contained in the edible portion) of differ food materials, the calculations can be made on the basis of 1 pou of this water-free edible portion. This is an excellent method for c paring the actual values of two or more food materials as sources protein or of energy. The following figures show the comparison milk and a few other foods on this basis:

*Nutrients and energy in one pound of the water-free edible portion of several food materi*

| Food materials. | Protein. | Fat. | Carbohydrates. | Mineral matter. | Fu val |
|---|---|---|---|---|---|
| | *Pound.* | *Pound.* | *Pound.* | *Pound.* | *Calo* |
| Whole milk | 0.25 | 0.31 | 0.39 | 0.05 | 2 |
| Skim milk (0.3 per cent fat) | .36 | .03 | .55 | .06 | 1 |
| Buttermilk | .33 | .06 | .53 | .08 | 1 |
| Cheese | .39 | .52 | .03 | .06 | 2 |
| Beef, round | .57 | .40 | .......... | .03 | 2 |
| Smoked ham | .26 | .66 | .......... | .08 | 2 |
| Wheat flour | .13 | .01 | .85 | .01 | 1 |
| Wheat bread | .15 | .02 | .82 | .01 | 1 |
| Potatoes | .10 | .01 | .85 | .04 | 1 |
| Apples | .03 | .03 | .92 | .02 | 1 |

It is seen from the above table that whole milk, skim milk, a buttermilk are all nitrogenous foods, though not as highly nitrogen as the meats. Not only do they furnish a large proportion of nit gen, but on account of their fuel ingredients (fats and carbohydrat they are useful as sources of energy. One pound of the dry substa of skim milk contains nearly three times the protein and very nea the same fuel value as 1 pound of wheat flour. It is only on account the large proportion of water that skim milk can not be used to a m greater extent than it is. Both skim milk and whole milk should, has been urged above, be used much more extensively in cooking.

Chart I (p. 17) shows the relative composition of various foods compared with whole and skim milk.

## THE USE OF MILK WITH OTHER FOODS.

Milk is often spoken of as a "perfect food," but there are th reasons why it can not be considered a perfect food for adults. (1) proportion of water is so large that great quantities would have to consumed per day (from 4 to 5 quarts) in order to obtain the necess nutrients. (2) The protein is present in rather large quantities as c pared with the fats and carbohydrates. Thus the milk necessar furnish the 0.28 pound of protein, estimated to be required by a la ing man per day, would only yield 2,700 calories fuel value, while n in sufficient quantity to furnish the 3,500 calories fuel value estima to be required would yield 0.35 pound of protein. (3) It is a w recognized fact that the digestive functions require that the food s have a certain bulk other than water. Cattle can not generally maintained in health upon a condensed ration such as grain; they se

## CHART I.—COMPOSITION OF MILK AND OTHER FOOD MATERIALS.

*Nutritive ingredients, refuse, and fuel value.*

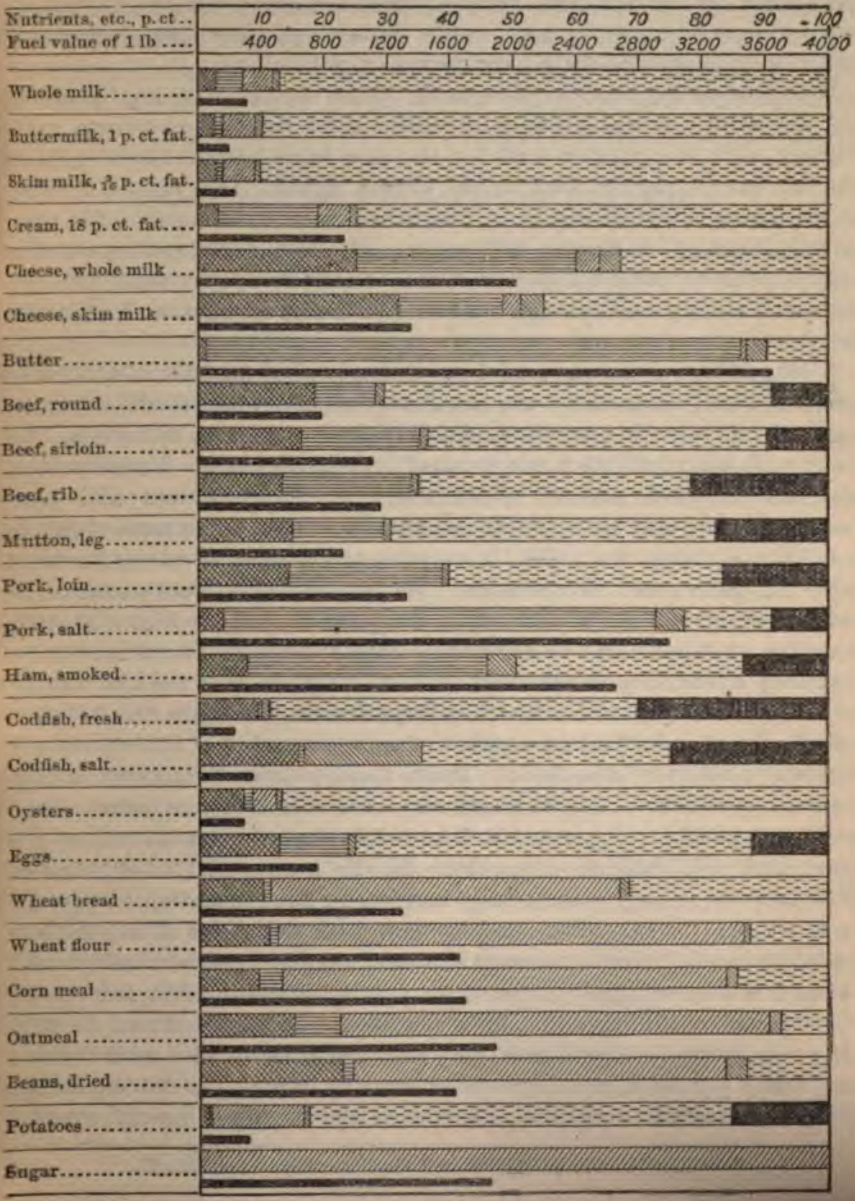
Nutrients.
- ▩ Protein.
- ☰ Fats.
- ▨ Carbo-hydrates.
- ▧ Mineral matters,

Non-nutrients.
- ▤ Water.
- ■ Refuse.

Fuel value.
- ▬ Calories.

*Protein* compounds, e. g., lean of meat, white of egg, casein (curd) of milk, and gluten of wheat, make muscle, blood, bone, etc.

*Fats*, e. g., fat of meat, butter, and oil, } serve as fuel to yield heat and muscular power.
*Carbohydrates*, e. g., starch and sugar, }



to require a certain distention of the stomach, such as is brought about by the fiber (cellulose or woody matter) of grass or hay. In like manner it seems desirable that man should have a certain amount of material in his food to produce distention or to promote peristaltic action of the intestines, or for other purposes not well understood.

While milk alone can not be considered as a perfect diet, at least for healthy adults, it is of especial value as a food for invalids. It is, as a rule, easily taken, easily digested, does not irritate the alimentary canal, and the diet is more readily under the control of the physician both as regards quantity and quality than when other foods are used. Life can be supported for a long period on milk alone.

Milk is a perfect food for the young of the species of animal producing the milk. Cows' milk is a perfect food for the new-born calf. Human milk is a perfect food for the new-born babe. Cows' milk is not, however, a perfect food for the human infant. One reason is that, as will be seen by reference to the table on p. 6, woman's milk contains less protein and more milk sugar. Numerous explanations of the defects of cows' milk for the nutrition of infants are current, but the subject is hardly well enough understood to-day to warrant its discussion here.

While milk can not in itself be called a perfect food for adults, it is unusually well adapted for use in connection with other foods, either in its uncooked form or incorporated and cooked with other materials. In many culinary products it can be used instead of water. Bread mixed with milk should contain about one-tenth more protein and one-twentieth more fuel than bread mixed with water. The same thing is true of rolls, buns, etc. Milk is very generally used in many kinds of cake and pastry and in custards. Where desirable from economical reasons, or as a means of increasing the proportional amount of protein in a diet, skim milk can be advantageously substituted for whole milk.

A very interesting experiment was recently made at the University of Maine, in cooperation with this Department,[1] in which the effect of a limited and an unlimited amount of milk was tried at the university boarding house or "commons." From these studies the following conclusions were drawn: (1) The dietaries in which milk was more abundantly supplied were somewhat less costly than the others and at the same time were fully as acceptable; (2) the increased consumption of milk had the effect of materially increasing the proportion of protein in the diet; (3) the milk actually supplied the place of other food materials and did not, as many suppose, simply furnish an additional amount of food without diminishing the quantity of other materials; (4) the results indicate that milk should not be regarded as a luxury, but as an economical article of diet which families of moderate income may freely purchase as a probable means of improving the character of the diet and of cheapening the cost of the supply of animal foods.

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[1] See U. S. Dept. Agr., Office of Experiment Stations Bul. 37.

## NUTRITIVE VALUE OF MILK AND ITS COST.

A very valuable investigation on this subject has been lately made the New Jersey Experiment Station in cooperation with the Depart- nt of Agriculture. Samples of milk as sold from the milk carts and retail dealers at their stores in the cities of New Brunswick, New- , Trenton, and Camden were collected by representatives of the tion and analyzed. The price per quart in each case was noted. In rge number of instances inquiries were made among the dairies as reed, feeding, and care of the cows. The handling of the milk by dairymen and the wholesale and retail dealers was also noted. The owing statements are based on the report of this investigation Professor Voorhees,[1] of the New Jersey Agricultural Experiment tion.

### RELATIVE COST PER POUND OF NUTRIENTS.

he fact that milk varies in composition shows at once that at a form price per quart there is a wide variation in the cost of the rients to the consumer. It will be observed from a study of the rage composition of milk that as the total solids in the milk increase percentage of fat is increased in greater proportion than the solids t fat. The consumer not only secures his total solids in the richer lk at a lower cost per pound, but also obtains a product which is very ch richer in material to supply the body with heat and muscular ce. The facts regarding the variation in the cost and quality of the trients contained in milk show very clearly that the standard now use as the basis of sale, viz, the quart, is illogical and unfair both to consumer and to the producer of good milk. The dairyman who es his milk to the creamery usually sells it on the basis of the ount of fat it contains, that is, the amount of fat is the measure of ue. In like manner in the retailing of milk the fat content should taken as a standard rather than the quart. For instance, the aver- e fat content of a large number of milks examined for which at the erage price of 8 cents per quart $4 per hundred were paid, was, in und numbers, 4 per cent, or 4 pounds of fat per hundred pounds of lk. If milk containing 4 per cent of fat is worth 8 cents per quart, lk containing 3.5 per cent would, on the same basis, be worth 7 cents r quart, 3 per cent milk only 6 cents per quart, and 5 per cent milk cents per quart. If the fat content standard were adopted the con- mer would be protected in the sense that he would receive just what paid for, and the producer of high quality product the advantage of higher price, which fairly belongs to him, because of the greater cost producing milk of a better quality. Inasmuch as this method of rchasing milk by actual composition is now used in many creameries ith entire satisfaction both to the seller and the buyer, it should be entirely practicable under present conditions for even the smaller producers and dealers to guarantee a product containing a reasonably definite content of fat. Instruments are available for testing the fat content of milk which are inexpensive and simple in operation, and the chief causes of variation in the quality of milk under improved methods of feeding and management are well known and under the control of the dairyman. It remains for the more intelligent consumers and producers alike to demand that the system be adopted.

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[1] U. S. Dept. Agr., Office of Experiment Stations Bul. 35.

The use of the fat content as a standard, as above suggested, is the more reasonable, because (1) the fat is the most variable ingredient; (2) a milk rich in fat is generally more apt to be rich in other nutrients, and vice versa; and (3) the most common adulterations of milk reduce the proportion of fat either by skimming or by adding water.

On the other hand, the actual value of milk for nourishment does not depend wholly or chiefly upon the amount of fat. The protein and sugar are of equal importance. Indeed, in one respect the protein is the most valuable of all because it is the nutriment most apt to be deficient in our ordinary food. On this last account, indeed, the fat is of less consequence from the standpoint of general nutritive value than the protein.

## COMPARISON OF MILK AND OTHER FOOD MATERIALS—COST OF NUTRIENTS.

In considering the relative values of any two food materials there are two principal factors to be taken into account—the protein content and the fuel value. A definite comparison of the relative pecuniary economy of two or more foods must be made on the basis of the relative cost of the protein content and also on that of the fuel value. Between these two bases we can have no fixed ratio. The following table shows the amount of whole milk, or of skim milk, necessary to furnish the protein and energy equivalent to that contained in one pound of each of a number of different food materials:

*Cost of nutrients in milk as compared with other food materials.*

| Food materials. | Whole milk. | | Skim milk. | |
|---|---|---|---|---|
| | Amount. | Cost at 6 cents per quart. | Amount. | Cost at |
| One pound of— | | | | |
| Beef— | *Quarts.* | *Cents.* | *Quarts.* | *Cents.* |
| Round furnishes protein equivalent to | 2.7 | 16 | 2.7 | |
| Round furnishes fuel value equivalent to | 1.3 | 8 | 2.6 | |
| Shoulder clod furnishes protein equivalent to | 2.9 | 17 | 2.9 | |
| Shoulder clod furnishes fuel value equivalent to | 1.2 | 7 | 2.5 | |
| Sirloin furnishes protein equivalent to | 2.4 | 14 | 2.4 | |
| Sirloin furnishes fuel value equivalent to | 1.6 | 10 | 3.2 | |
| Mutton loin furnishes protein equivalent to | 2.0 | 12 | 2.0 | |
| Mutton loin furnishes fuel value equivalent to | 2.2 | 13 | 4.4 | |
| Pork— | | | | |
| Fresh, furnishes protein equivalent to | 2.1 | 13 | 2.1 | |
| Fresh, furnishes fuel value equivalent to | 2.1 | 13 | 4.1 | |
| Salt: Fat furnishes protein equivalent to | 2.3 | 2 | .3 | |
| Salt: Fat furnishes fuel value equivalent to | 5.7 | 34 | 11.3 | |
| Smoked ham furnishes protein equivalent to | 2.0 | 12 | 2.0 | |
| Smoked ham furnishes fuel value equivalent to | 2.5 | 15 | 5.0 | |

*Cost of nutrients in milk as compared with other food materials*—Continued.

| Food materials. | Whole milk. | | Skim milk. | |
|---|---|---|---|---|
| | Amount. | Cost at 6 cents per quart. | Amount. | Cost at 3 cents per quart. |
| One pound of— | *Quarts.* | *Cents.* | *Quarts.* | *Cents.* |
| Chicken furnishes protein equivalent to | 2.2 | 13 | 2.2 | 7 |
| Chicken furnishes fuel value equivalent to | .5 | 3 | 1.0 | 3 |
| Salt cod furnishes protein equivalent to | 2.4 | 14 | 2.4 | 7 |
| Salt cod furnishes fuel value equivalent to | .5 | 3 | 1.0 | 3 |
| Oysters, "solid," furnishes protein equivalent to | 1.9 | 11 | 1.9 | 6 |
| Oysters, "solid," furnishes fuel value equivalent to | .4 | 2 | .7 | 2 |
| Wheat flour furnishes protein equivalent to | 1.7 | 10 | 1.7 | 5 |
| Wheat flour furnishes fuel value equivalent to | 2.5 | 15 | 5.0 | 15 |
| Wheat bread furnishes protein equivalent to | 1.4 | 8 | 1.4 | 4 |
| Wheat bread furnishes fuel value equivalent to | 1.9 | 11 | 3.7 | 11 |
| Beans, dried, furnishes protein equivalent to | 3.3 | 20 | 3.3 | 10 |
| Beans, dried, furnishes fuel value equivalent to | 2.4 | 14 | 4.8 | 14 |
| Potatoes furnishes protein equivalent to | .3 | 2 | .3 | 1 |
| Potatoes furnishes fuel value equivalent to | .5 | 3 | 1.0 | 3 |
| Turnips furnishes protein equivalent to | .2 | 1 | .2 | 1 |
| Turnips furnishes fuel value equivalent to | .2 | 1 | .4 | 1 |

The quantity of milk in the above table is given in quarts and tenths of a quart. It is probable that 6 cents a quart for whole milk and 3 cents a quart for skim milk, the prices assumed in the table, represent as nearly the average retail prices paid by consumers as any rate that could be taken. Of course many pay much more and others much less than 6 cents a quart for whole milk. For those who pay more or less, the actual cost of the milk equivalent to the protein or fuel value of 1 pound of any of the foods enumerated is easily calculated by multiplying the equivalent number of quarts of milk by the price paid per quart. This table shows that 1 pound of sirloin steak (costing from 16 to 22 cents) contains the same amount of protein that would be obtained in 2.4 quarts of whole milk costing, at 6 cents per quart, 14 cents, and the same fuel value that would be obtained in 1.6 quarts of whole milk costing 10 cents. Skim milk would furnish the energy at the same price as the whole milk, but the protein would cost only half as much as when furnished by whole milk.

Whole milk and skim milk contain practically the same amount of protein, but the former costs at least twice as much per quart. As a source of protein, therefore, skim milk is twice as economical as whole milk. On the other hand, the fuel value of skim milk is practically but one-half that of whole milk, so that a given amount of energy is furnished for the same price, either in whole milk or skim milk.

From the above table it will be seen that 16 cents' worth of whole milk or 8 cents' worth of skim milk would furnish the same amount of protein as would be obtained in 1 pound of beef round, while the corresponding fuel value would be obtained in 8 cents' worth of either kind of milk. Compared with round steak at from 12 to 16 cents a pound the whole milk certainly is as economical and skim milk a more economical food material. The same point is illustrated with other animal foods, especially with those whose chief value lies in their content of protein. Milk can not, however, be substituted in place of an essentially energy-yielding food, such as salt fat pork.

The cereal foods, wheat flour and other flours, bread, crackers, etc., as also beans and peas, are a much cheaper source of nutrients than milk. It is, however, impracticable to live altogether on these foods even if economical reasons should make it desirable. Some other foods are necessary, and among these milk is one of the best and as a rule one of the most economical.

Chart II (p. 23) shows the quantities of nutrients obtained in 10 cents' worth of whole and of skim milk, at different prices per quart, as compared with 10 cents' worth of other food materials at common prices.

## DAILY MENUS CONTAINING MILK.

### DIETARY STANDARDS.

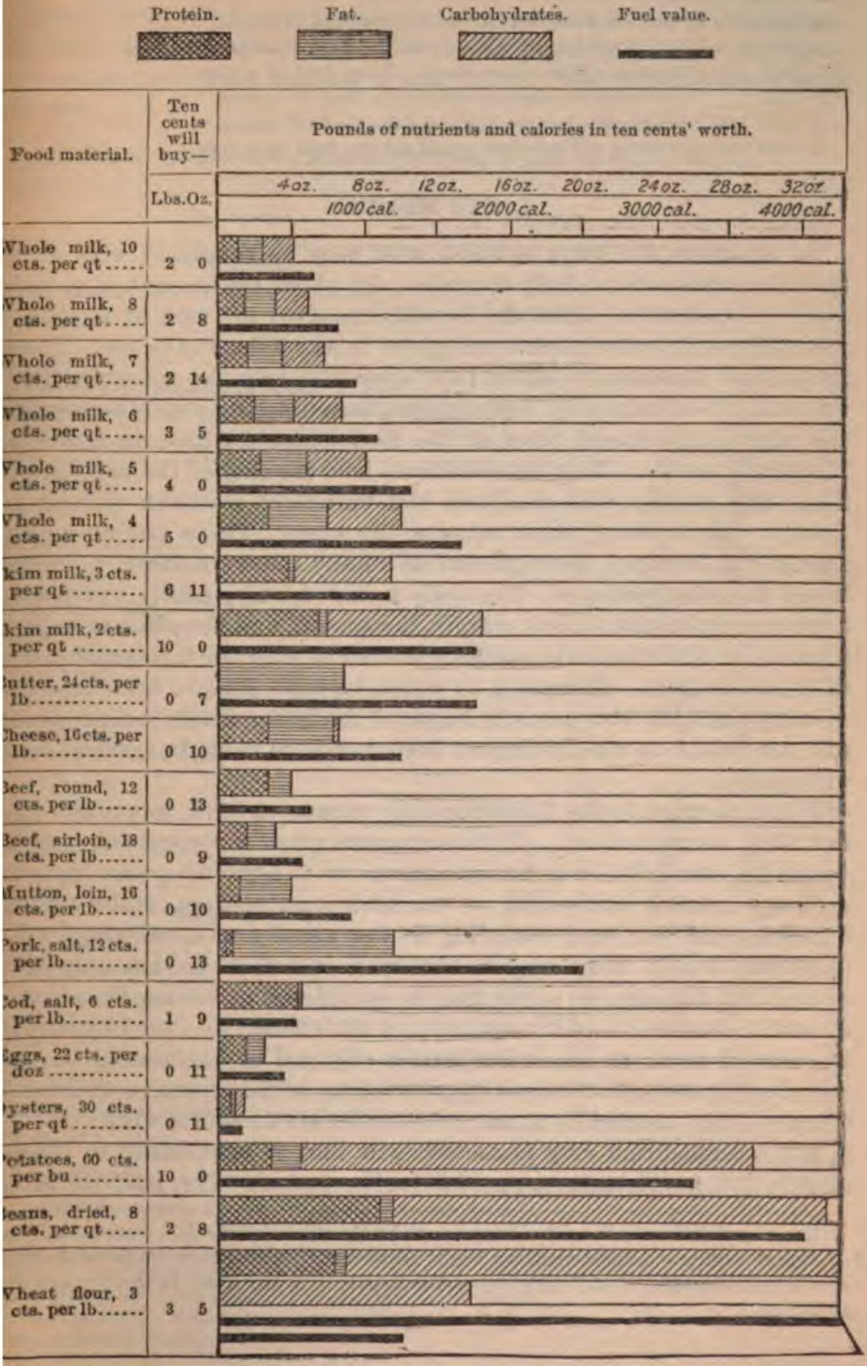
In order that food shall be adapted to the needs of the body, it should have the protein and fuel ingredients in the proper proportions. It has been assumed from the most accurate observations available that an average man doing an ordinary amount of manual labor—a carpenter or mason, for instance—requires in his daily food about 0.28 of a pound of protein, and in addition enough fats and carbohydrates to make the fuel value 3,500 calories. Men in professional life, with less muscular work, generally need less. Standards prepared for men of this class call for 0.22 to 0.25 of a pound of protein and from 2,700 to 3,000 calories of energy. Various combinations of foods for daily dietaries on either of the bases noted above may be made by using calculations based on the chemical composition of various foods. A few such calculations are here given in the form of daily menus which give the actual amounts of different food materials thus required by a family equivalent to four men at ordinary manual labor.

Such a family might, for example, consist of a mechanic and wife with four children—two girls of 12 and 6 and two boys of 10 and 8 years, respectively. Here it would be assumed that the man was engaged at moderately hard manual work. In like manner, the family might consist of a man of sedentary occupation—a bookkeeper, for example—his wife, three children of 11, 9, and 6 years, and a female servant. Estimated in the same way, a day laborer's family, consisting of a father and mother with three children of 1, 3, and 6 years of age, would be equivalent to three men at active work, and would require three-fourths of the quantities in the following menus.

The equivalent of any family in terms of one adult man at moderate work one day can be easily calculated by the use of the following factors, which are based in part upon experimental data and in part upon arbitrary assumption. While these factors do not represent the proportional amount consumed by every child of a given age, they are

## CHART II.—PECUNIARY ECONOMY OF MILK AND OTHER FOODS.

*Amounts of actual nutrients obtained in different food materials for ten cents.*



probably on the whole as nearly accurate as can be obtained without considerable more experimental data. The factors are as follows:

A woman requires about 0.8 the food of a man.[1]
A boy 14 to 16 years old requires about 0.8 the food of a man.
A girl 14 to 16 years old requires about 0.7 the food of a man.
A child 10 to 13 years old requires about 0.6 the food of a man
A child 6 to 9 years old requires about 0.5 the food of a man.
A child 3 to 5 years old requires about 0.4 the food of a man.
A child under 2 years old requires about 0.3 the food of a man.

## THE MENUS.

To illustrate the ways in which milk may be combined with other food materials to form daily dietaries with about the amount of protein and the fuel value called for by the standard for men at moderate muscular work, a few menus are given in the following pages. These menus are intended to show how approximately the same nutritive value may be obtained by food combinations differing widely as regards the number, kind, and price of the food materials used to make up three daily meals. They also illustrate how the cost of the daily menu may vary greatly with the kind and variety of materials purchased though the nutritive value remains the same. These sample menus should not, however, be regarded as in any sense "models" to be followed in actual practice. The daily menus for any family will necessarily vary with the market supply, the season, and the rèlative expensiveness of different food materials, as well as with the tastes and purse of the consumers. The point to which we wish here to draw especial attention is that the prudent buyer of foods for family consumption can not afford to wholly neglect their nutritive value in making such purchases.

With reference to the following daily menus several points must be definitely borne in mind. (1) The amounts given represent about what would be called for in a family equivalent to four full-grown men at ordinary manual labor, such as machinists, carpenters, mill-workers, farmers, truckmen, etc., according to the usually accepted standards. Sedentary people would require somewhat less than the amounts here given. (2) Children as a rule may be considered as having "moderate muscular exercise," and it may easily be understood that the 14-year-old boy eats as much as his father who is engaged in business or professional occupation, both requiring, according to the tentative standard, 0.8 of the food needed by a man with moderate muscular work. (3) It is not assumed that any housewife will find it convenient to follow exactly the proportions suggested in the menus. The purpose is to r about what amounts and proportions of food materials would required nutrients.

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[1] These comparisons are with a man at moderate muscular work. A man without any considerable muscular exercise might require only the eight-tenths here allotted to a woman engaged in ordinary household duties, or a boy from 14 to 16 years old at school.

I calls for a daily expenditure of 41½ cents per person, the t items of expense therein being the bacon and eggs, the sirup, b, and the chicken croquettes. It is, perhaps, more elaborate tly than many families would desire. The detailed menu is as :

MENU I.—*For family equivalent to 4 men at moderate muscular work.*

| Food materials. | Weight. | | Cost. | Protein. | Fuel value. |
|---|---|---|---|---|---|
| *Breakfast.* | *Lbs.* | *Oz.* | *Cents.* | *Pounds* | *Calories.* |
| meal | 0 | 3 | 2½ | 0.029 | 350 |
| | | 6 | | .012 | 61 |
| | | 2 | | ........ | 232 |
| | | 8 | 8 | .046 | 1,390 |
| | | 8 | 8 | .065 | 322 |
| toes | 1 | 0 | 1½ | .018 | 325 |
| t cakes, prepared buckwheat | | 8 | 4 | .034 | 780 |
| p | | 4 | 3 | ........ | 327 |
| | | 8 | 2 | .048 | 603 |
| | | 1½ | 3 | ........ | 225 |
| | ........ | | 3½ | .010 | 410 |
| l | ........ | | 35½ | .262 | 5,028 |
| *Dinner.* | | | | | |
| | 1 | 0 | 15 | .020 | 45 |
| , leg | 1 | 8 | 30 | .228 | 1,282 |
| tatoes | 1 | 0 | 2 | .018 | 325 |
| | 1 | 0 | 3 | .009 | 52 |
| , shelled | 1 | 8 | 6 | .072 | 382 |
| | | 4 | 4 | .029 | 410 |
| | | 3 | 3 | .049 | 369 |
| ling: | | | | | |
| our | | 4 | 9 | .028 | 410 |
| | | 4 | | ........ | 465 |
| | | 2 | | .016 | 81 |
| ilk | | 4 | | .008 | 81 |
| ruit | | 8 | | .013 | 817 |
| ce for pudding: | | | | | |
| | | 2 | 5 | .016 | 81 |
| ilk | | 4 | | .010 | 102 |
| ugar | | 4 | | ........ | 465 |
| | | 6 | 1½ | .036 | 452 |
| | | 1 | 2 | ........ | 217 |
| ee | ........ | | 8½ | .010 | 410 |
| l | ........ | | 84 | .562 | 6,446 |
| *Supper or lunch.* | | | | | |
| oquettes: | | | | | |
| n meat | | 8 | 18 | .114 | 250 |
| | | 1 | | .007 | 103 |
| | | 1 | | .001 | 13 |
| | | 2 | | .016 | 81 |
| | | 2 | | .012 | 151 |
| | | 8 | 3 | .005 | 42 |
| | | 8 | 2 | .048 | 603 |
| | | 1½ | 3 | ........ | 325 |
| | | 6 | 3 | .026 | 619 |
| | 1 | 0 | 8 | .010 | 175 |
| or cocoa, with milk and sugar, cream | | 1½ | 5 | .030 | 625 |
| l | ........ | | 42 | .269 | 2,987 |
| l per day | ........ | | 161½ | 1.093 | 14,461 |
| l for one man | ........ | | 40 | .270 | 3,615 |

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ures given for butter in these menus are based on the percentage composition as given in Agr., Office of Experiment Stations, Bul. 28.. This differs slightly from that given on p. 15, recently made average of a larger number of analyses.

ues given under coffee include in all cases the milk and cream and the sugar that would e used therein.

A family equivalent to four men having little muscular exercise—i. e., men with sedentary occupation—would require but about 0.8 the quantities indicated in the above menu. It would be very doubtful, however, if they would eat proportionally less of every food material. It would, in fact, be more probable that the amounts of meat, fish, eggs, potatoes, and bread eaten would be reduced to a much greater amount than fruit, pastry, coffee, etc.

Menu I modified so as to furnish the amount of nutrients required by a family equivalent to four adults with little muscular exercise would be as follows:

*Menu I modified for a family equivalent to four adults with little exercise.*

*Breakfast.*—Cereal, 2½ ounces; milk, 6 ounces; sugar, 2 ounces; bacon, 6 ounces; potatoes, 12 ounces; buckwheat, prepared, 6 ounces; maple sirup, 3 ounces; other items as in Menu I.

*Dinner.*—Roast lamb, leg, 1 pound 4 ounces; green peas, shelled, 1 pound 4 ounces; macaroni, 3 ounces; cheese, 2 ounces; other items as in Menu I.

*Supper.*—Chicken croquettes, chicken meat, 6 ounces; flour, ¾ ounce; onion, ¼ ounce; butter, 1½ ounces; lettuce, 6 ounces; bread, 6 ounces; other items as in Menu I.

By reducing the materials in this menu to the quantities noted above, the average cost of the three meals would be about 37 cents per man, and would furnish not far from 0.24 pound protein and a fuel value of about 3,090 calories to each person.

In Menu II the day's food costs 29½ cents. The largest single item is the meat for dinner. The one giving the least food return in actual nutriment for its cost is the fruit. The amount of protein furnished by the breakfast and supper is small as compared with the fuel value of the food. Consequently, for dinner some meat is used which will furnish considerable protein, but not an excessive amount of fuel ingredients, otherwise the ration will be one-sided Beef, veal, and fish are meats giving a large amount of protein as compared with the fuel value, and it is from one of these classes that the meat is to be selected. The choice might fall on a knuckle of veal for a stew, fried fresh cod, or some lean cut of beef. In this menu the shoulder of beef is chosen. This, when properly boiled, gives a meat very tender, juicy, and palatable; when improperly cooked it adds more odium to the very unjustly despised "beef stew" and "pot roast." If desired, a veal shoulder roast may be substituted. It would require 2½ pounds of this to replace the beef shoulder, and would cost about 30 cents at the rates here assumed. This would make the cost per person about 31 cents for the day.

ails of this menu are as follows:

NU II.—*For family equivalent to 4 men at moderate muscular work.*

| Food materials. | Weight. | Cost. | Protein. | Fuel value. |
|---|---|---|---|---|
| *Breakfast.* | *Lbs. Oz.* | *Cents.* | *Pounds.* | *Calories.* |
| | 0 12 | 6 | 0.005 | 217 |
| al | 2 | 3 | .019 | 232 |
| | 8 | | .016 | 162 |
| | 2 | | ........ | 232 |
| et) | 2 | 3 | .016 | 207 |
| | 8 | 9 | .065 | 322 |
| | 1 0 | 4 | .096 | 1,206 |
| | 2½ | 5 | ........ | 542 |
| | ........ | 5 | .015 | 615 |
| | ........ | 35 | .232 | 3,735 |
| *Dinner.* | | | | |
| houlder | 2 0 | 24 | .386 | 1,670 |
| | 1 12 | 2 | .031 | 569 |
| | 1 12 | 6 | .039 | 850 |
| | 1½ | | ........ | 880 |
| g: | | | | |
| | 4 | 10 | .024 | 301 |
| | 1 8 | | .049 | 487 |
| | 2 | | .016 | 81 |
| | 3 | | ........ | 350 |
| | ½ | | ........ | 108 |
| | 12[1] | 3 | .071 | 904 |
| | 1½ | 3 | ........ | 325 |
| | 2 | 2 | .032 | 246 |
| | ........ | 5 | .015 | 615 |
| | ........ | 55 | .663 | 6,386 |
| *Supper or lunch.* | | | | |
| , shoulder | 10 | 10 | .084 | 682 |
| s: | | | | |
| | 10 | 2 | .011 | 203 |
| | ½ | | ........ | 132 |
| ar | 12 | 8 | .085 | 1,230 |
| | 2 | | .016 | 81 |
| | 1 | | ........ | 217 |
| s: | | | | |
| | 12 | 3 | .003 | 191 |
| | 3 | | ........ | 350 |
| | 4 | 2 | .017 | 412 |
| | ........ | 3½ | .010 | 410 |
| | ........ | 28½ | .220 | 3,908 |
| er day | ........ | 118½ | 1.121 | 14,029 |
| r one man | ........ | 29⅝ | .280 | 3,507 |

[1] Weight with pods.

It is customary in very many families to make some additional pr
ation for the Sunday table. In the following menu is given a rat
iore elaborate and varied diet, such as might be prepared for Sund
'he estimated cost per man per day of this ration is 46 cents, the ch
ems being the fruit, chicken, and ice cream. The details of th
ienu are as follows:

MENU III.—*For family equivalent to 4 men at moderate muscular work.*

| Food materials. | Weight. | | Cost. | Protein. | Fu val |
|---|---|---|---|---|---|
| *Breakfast.* | *Lbs.* | *Oz.* | *Cents.* | *Pounds.* | *Calo* |
| ranges, 4 | 1 | 8 | 10 | 0.009 | |
| ereals, wheat preparation | | 4 | 2 | .001 | |
| ilk | | 4 | | .008 | |
| ugar | | 2 | | ........ | |
| ried perch: | | | | | |
| Perch | 1 | 0 | 8 | .072 | |
| Lard | | ¼ | | ........ | |
| yster fritters: | | | | | |
| ½ pint oysters | | 8 | 11 | .031 | |
| ½ pint milk | | 8 | | .016 | |
| 1 cup flour | | 4 | | .028 | |
| reamed potatoes: | | | | | |
| 1 pint potatoes | 1 | 0 | 5 | .018 | |
| ½ pint milk | | 8 | | .016 | |
| Butter | | 1 | | ........ | |
| orn-meal muffins: | | | | | |
| 1 cup corn meal | | 6 | 4½ | .033 | |
| ½ cup flour | | 2 | | .014 | |
| Sugar | | 1 | | ........ | |
| 1 egg | | 2 | | .016 | |
| 1½ cups milk | | 10 | | .021 | |
| utter | | 2 | 4 | ........ | |
| offee or tea | ........ | | 5 | .015 | |
| Total | ........ | | 49½ | .328 | |
| *Dinner.* | | | | | |
| oast chicken: | | | | | |
| Chicken | 2 | 8 | 40 | .370 | |
| Bread | | 4 | | .024 | |
| Butter | | ½ | | ........ | |
| Onion | | 1 | | .001 | |
| ice croquettes: | | | | | |
| Rice | | 4 | 4 | .020 | |
| 1 egg | | 2 | | .018 | |
| Sugar | | ½ | | ........ | |
| ashed potatoes | | 8 | 1 | .009 | |
| aked sweet potatoes | | 8 | 1 | .007 | |

fourth menu the daily food costs about 26 cents per man. lk is introduced as a beverage for supper instead of tea or n this way a ration, which would otherwise be slightly defi- protein, is supplied with the required amount with the addi- it very little of fats and carbohydrates, i. e., fuel ingredients. found that the general tendency in the diet, especially where considerable variety of pastry and desserts, is toward too large ion of fats and carbohydrates as compared with the protein. be obviated either by the use of more and leaner meats, fish, im milk or buttermilk, and cheese.

xu IV.—*For family equivalent to 4 men at moderate muscular work.*

| Food materials. | Weight. |  | Cost. | Protein. | Fuel value. |
|---|---|---|---|---|---|
| *Breakfast.* | *Lbs.* | *Oz.* | *Cents.* | *Pounds.* | *Calories.* |
|  | 2 | 0 | 2 | 0.008 | 510 |
| y |  | 8 | 4½ | .041 | 823 |
|  |  | 10 |  | .020 | 202 |
|  |  | 3 |  | ........ | 350 |
| n |  | 10 | 11 | .090 | 650 |
|  |  | 8 | 1 | .009 | 162 |
|  |  | 4 | 5 | .032 | 162 |
| ur |  | 8 |  | .057 | 820 |
|  |  | 2 | 4 | ........ | 435 |
|  | ........ |  | 3½ | .010 | 410 |
|  | ........ |  | 31 | .276 | 4,524 |
| *Dinner.* |  |  |  |  |  |
|  | 2 | 0 | 6 | .036 | 370 |
| oulder | 2 | 0 | 20 | .332 | 1,350 |
|  | 3 | 0 | 4½ | .054 | 975 |
| ing: |  |  |  |  |  |
|  |  | 2 | 8 | .016 | 81 |
|  | 1 | 8 |  | .006 | 382 |
| l |  | 4 |  | ........ | 1,055 |
| r |  | 4 |  | .028 | 410 |
| npling: |  |  |  |  |  |
|  |  | 1 | 3 | ........ | 217 |
|  |  | 4 |  | ........ | 465 |
|  |  | 12 | 3 | .071 | 904 |
|  |  | 1 | 2 | ........ | 217 |
|  | ........ |  | 3½ | .010 | 410 |
|  | ........ |  | 50 | .553 | 6,836 |
| *Supper or lunch.* |  |  |  |  |  |
| corned beef |  | 8 | 6 | .142 | 560 |
| ette |  | 8 | 1 | .009 | 162 |
|  |  | 12 | 4 | .070 | 1,297 |
|  |  | 1½ | 3 | ........ | 325 |
|  | 1 | 4 | 7 | .007 | 400 |
|  | 1 | 6 | 2 | .046 | 234 |
|  | ........ |  | 23 | .274 | 2,978 |
| or day | ........ |  | 104 | 1.103 | 14,338 |
| or one man | ........ |  | 26 | .275 | 3,585 |

stration of what was said above concerning the tendency of a tion to contain too large a proportion of fuel ingredients (fats, igar, etc.) as compared with the amount of protein, the follow- n may be cited (No. 5). The changes necessary to obtain the roportions are illustrated in menu No. 6.

It is, of course, not important that each meal, or the total food of ea individual day, should have just the right amount of nutrients, or th the proportions of protein and fuel ingredients should be exactly c rect so as to make the meal or day's diet well balanced. The bod continually storing nutritive materials and using them. It is dependent any day upon the food eaten that particular day. Hence excess one day may be made up by a deficiency the next or vice ve Healthful nourishment requires simply that the nutrients as a wh during longer or shorter periods, should be fitted to the actual need the body for use.

MENU V.—*For family equivalent to 4 men at moderate muscular work.*

| Food materials. | Weight. | | Cost. | Protein. |
|---|---|---|---|---|
| *Breakfast.* | *Lbs.* | *Oz.* | *Cents.* | *Pounds.* |
| Bananas, 4 (or grapes, 1 pound) | 1 | 4 | 6½ | 0.009 |
| Breakfast cereal | | 4 | 3 | .031 |
| Milk | | 6 | | .012 |
| Sugar | | 2 | | ........ |
| Mutton chops | 1 | 4 | 20 | .165 |
| Potatoes | 1 | 0 | 1½ | .018 |
| Butter | | 3 | 6 | ........ |
| Rolls | | 12 | 4 | .077 |
| Coffee | ........ | ........ | 3½ | .010 |
| Total | ........ | ........ | 44½ | .322 |
| *Dinner.* | | | | |
| Tomato soup | 2 | 0 | 12 | .036 |
| Roast pork | 2 | 8 | 32 | .353 |
| Potatoes | 1 | 4 | 1½ | .022 |
| Turnips | | 8 | 1 | .005 |
| Tapioca pudding: | | | | |
| Tapioca | | 3 | 7 | .001 |
| Apples | 1 | 0 | | .004 |
| Sugar | | 2 | | ........ |
| Cream | | 4 | | .006 |
| Coffee | ........ | ........ | 3½ | .010 |
| Total | ........ | ........ | 57 | .437 |
| *Supper.* | | | | |
| Milk toast: | | | | |

:NU VI.—*For family equivalent to 4 men at moderate muscular work.*

| Food materials. | Weight. | | Cost. | Protein. | Fuel Value. |
|---|---|---|---|---|---|
| *Breakfast.* | *Lbs.* | *Oz.* | *Cents.* | *Pounds.* | *Calories.* |
| r grapes, 1 pound) | 1 | 4 | 6½ | 0.009 | 362 |
| eal |  | 4 | 3 | .031 | 421 |
|  |  | 8 |  | .016 | 162 |
|  |  | 1½ |  | ........ | 175 |
|  | 1 | 0 | 20 | .200 | 775 |
|  | 1 | 0 | 1½ | .018 | 325 |
|  |  | 3 | 6 | ........ | 653 |
|  |  | 12 | 4 | .077 | 1,148 |
|  | ........ |  | 3½ | .010 | 410 |
|  | ........ |  | 44½ | .361 | 4,431 |
| *Dinner.* |  |  |  |  |  |
|  |  | 8 | 5 | .121 | 820 |
|  |  | 1 |  | ........ | 217 |
|  |  | 1 |  | .007 | 103 |
| uck rib | 1 | 12 | 21 | .275 | 1,260 |
|  | 1 | 4 | 1½ | .022 | 406 |
|  |  | 8 | 1 | .005 | 67 |
| ing with lemon sauce: |  |  |  |  |  |
| r |  | 4 | 6½ | .028 | 410 |
|  |  | 3 |  | ........ | 850 |
|  |  | 1½ |  | ........ | 325 |
| c |  | 8 |  | .016 | 162 |
|  |  | 4 | 2½ | ........ | 465 |
| h |  | 1½ |  | ........ | 172 |
|  |  | ½ |  | ........ | 108 |
|  | ........ |  | 3½ | .010 | 410 |
|  | ........ |  | 41 | .484 | 5,275 |
| *Supper.* |  |  |  |  |  |
|  | 2 | 0 | 18 | .066 | 650 |
|  | 1 | 2 |  | .107 | 1,356 |
|  |  | 4 |  | ........ | 809 |
| h |  | 2 |  | ........ | 228 |
| n |  | 8 | 8 | .098 | 340 |
| s: |  |  |  |  |  |
|  |  | 8 | 1 | .009 | 162 |
|  |  | ½ |  | ........ | 132 |
|  |  | 6 | 4 | .026 | 619 |
|  | ........ |  | 3½ | .010 | 410 |
|  | ........ |  | 34½ | .316 | 4,766 |
| r day | ........ |  | 120 | 1.161 | 14,472 |
| r one man | ........ |  | 30 | .290 | 3,618 |

u VII the cost per day amounts to 21 cents, the protein to
ıd, and the fuel value to 3,410 calories. This ration is slightly
n fuel ingredients—those which supply the body with heat and
forces—and would best precede or follow one in which fatter
l more pastry were used, such, for example, as Menu V. If
ıe Indian pudding could be made with whole milk instead of
, when the fuel value per person would be increased to 3,500
ithout affecting the amount of protein, while the cost per man
increased about 1 cent. In this case the ration becomes well
in itself.

MENU VII.—*For family equivalent to 4 men at moderate muscular work.*

| Food materials. | Weight. | | Cost. | Protein. |
|---|---|---|---|---|
| *Breakfast.* | *Lbs.* | *Oz.* | *Cents.* | *Pounds.* |
| Oatmeal | 0 | 2 | 2 | 0.019 |
| Milk | | 6½ | | .012 |
| Sugar | | 1 | | ........ |
| Fresh pork sausage | 1 | 8 | 18 | .192 |
| Potatoes | | 12 | 1 | .013 |
| Bread | | 12 | 3 | .071 |
| Butter | | 2 | 4 | ........ |
| Coffee | ......... | | 3½ | .010 |
| Total | ......... | | 31½ | .317 |
| *Dinner.* | | | | |
| Beef, for stew | 2 | 8 | 15 | .347 |
| Potatoes | 1 | 8 | 2 | .027 |
| Turnips | | 8 | 1 | .005 |
| Bread | | 8 | 2 | .048 |
| Butter | | 1 | 2 | ........ |
| Indian pudding: | | | | |
| Corn meal | | 4 | 6 | .022 |
| Molasses | | 4 | | .007 |
| Butter | | ½ | | ........ |
| Skim milk | 2 | 0 | | .068 |
| Coffee | ......... | | 3½ | .010 |
| Total | ......... | | 31½ | .534 |
| *Supper.* | | | | |
| Corned-beef hash: | | | | |
| Corned beef, canned | | 8 | 6 | .142 |
| Potatoes | | 8 | 1 | .009 |
| Bread | | 12 | 3 | .071 |
| Butter | | 2 | 4 | ........ |
| Apples | | 12 | 1 | .003 |
| Milk | 2 | 0 | 6 | .066 |
| Total | ......... | | 21 | .291 |
| Total per day | ......... | | 84 | 1.142 |
| Total for one man | ......... | | 21 | .285 |

In these menus the amount of milk has, as a rule, been taken as r resenting somewhere near the average consumption. The amount milk can be increased in any of the menus given above either by s stituting it to some extent for coffee or tea, or by using more milk a smaller quantities of meats, butter, or eggs. Roughly speaking quart of whole milk could be substituted for half a pound of mea eggs and the amount of nutrients would be the same, while a pi milk would give as large a fuel value as 1½ ounces of butter, and addition considerable protein not furnished by the latter.

This replacement of meats by milk is illustrated in the followi menu, in which a diet with a rather small quantity of milk is changed as to include a much larger amount. Thus for breakfast the modified ration a pint and a half of milk is made to take place of half a pound of broiled steak. For dinner a quart of s milk (or buttermilk) is called for, or a glass for each person un some of it is used in the cooking. At the same time, 4 ounces roast pork is required. In the same way a glass of whole milk allowed each person for supper, or the bread can be made into toast and the most of the extra milk used in this way. This al the canned salmon to be reduced 6 ounces.

**Menu VIII.**—*For family equivalent to 4 men at moderate exercise.*

| Food materials. | Weight of food. With small amount of milk. | | Weight of food. With large amount of milk. | | Food materials. | Weight of food. With small amount of milk. | | Weight of food. With large amount of milk. | |
|---|---|---|---|---|---|---|---|---|---|
| *Breakfast.* | | | | | *Dinner*—Continued. | | | | |
| | *Lbs.* | *Oz.* | *Lbs.* | *Oz.* | | *Lbs.* | *Oz.* | *Lbs.* | *Oz.* |
| anas, apples, or pears | 0 | 12 | 0 | 12 | Apple fritters—Continued. | | | | |
| at preparation | | 4 | | 4 | Flour | | 2 | | 2 |
| : | | 8 | | 8 | 1 egg | | 2 | | 2 |
| ar | | 2 | | 2 | Lard | | 1½ | | 1½ |
| led sirloin steak | 1 | 4 | | 12 | Bread | | 8 | | 8 |
| ed potatoes | 1 | 8 | 1 | 8 | Butter | | 2 | | 2 |
| rolls | 1 | 0 | 1 | 0 | Extra skim milk | | | 2 | 0 |
| er | | 2½ | | 2½ | *Supper.* | | | | |
| a milk | | | 1 | 8 | | | | | |
| *Dinner.* | | | | | Canned salmon | 1 | 6 | 1 | 0 |
| | | | | | Potatoes | | 12 | | 12 |
| ato soup | 1 | 12 | 1 | 12 | Bread | | 8 | | 8 |
| t pork | 1 | 12 | 1 | 8 | Butter | | 2 | | 2 |
| hed potatoes | 1 | 4 | 1 | 4 | Berries, canned or fresh | | 8 | | 8 |
| nips | | 8 | | 8 | Extra milk | | | 2 | 0 |
| le fritters: | | | | | | | | | |
| Apples | | 8 | | 8 | | | | | |

*Cost, protein, and fuel value of the above.*

| | Cost. | Protein. | Fuel value. |
|---|---|---|---|
| *With small amount of milk.* | *Cents.* | *Pounds.* | *Calories.* |
| akfast | 48 | 0.39 | 5,300 |
| ner | 51 | .39 | 5,800 |
| per or lunch | 33½ | .34 | 3,200 |
| Total per day | 132½ | 1.12 | 14,300 |
| Total for one man | 33 | .28 | 3,575 |
| *With large amount of milk.* | | | |
| akfast | 43 | .36 | 5,270 |
| ner | 47½ | .41 | 5,400 |
| per or lunch | 34½ | .34 | 3,600 |
| Total per day | 125 | 1.11 | 14,270 |
| Total for one man | 31 | .28 | 3,567 |

Menus IX, X, and XI, following, are intended to illustrate how nouring food can be procured in sufficient quantities and moderate iety at a cost of not over 16 cents per day. The cost to the farmer ld be much less, since these menus call for considerable amounts of k, which is hardly worth more than one-half or one-third as much the farm as it costs in the towns and cities. Coffee has not always n indicated, but can be introduced for any meal at a cost of from ½ 1½ cents per cup, according to how much coffee is used in making the sion and how much sugar, milk, and cream are added.

**Menu IX.**—*For family equivalent to 4 men at moderate muscular work.*

| Food materials. | Weight. | | Cost. | Protein. | Fuel value. |
|---|---|---|---|---|---|
| *Breakfast.* | *Lbs.* | *Oz.* | *Cents.* | *Pounds.* | *Calories.* |
| Corn meal, in mush or cake | 0 | 5 | 1 | 0.022 | 414 |
| Milk | | 6 | 1 | .012 | 64 |
| Sugar | | 2 | ½ | ........ | 232 |
| Toast | | 10 | 2½ | .059 | 753 |
| Butter (24 cents per pound) | | 2 | 3 | ........ | 434 |
| Total | ........ | | 8 | .093 | 1,897 |
| *Dinner.* | | | | | |
| Beef roll (for roasting) | 3 | 0 | 15 | .417 | 2,280 |
| Potatoes | 1 | 8 | 2 | .026 | 466 |
| Beets | | 8 | 1 | .007 | 86 |
| Bread | | 10 | 2½ | .059 | 753 |
| Butter | | 2 | 3 | ........ | 434 |
| Total | ........ | | 23½ | .509 | 4,040 |
| *Supper.* | | | | | |
| Beans, baked | 2 | 0 | 6 | .446 | 3,180 |
| Pork | | 12 | 6 | .012 | 2,556 |
| Potatoes, fried | 1 | 8 | 2 | .026 | 458 |
| Lard | | 2 | 1 | ........ | 537 |
| Bread | | 10 | 2½ | .059 | 753 |
| Butter | | 2 | 3 | ........ | 434 |
| Total | ........ | | 20½ | .543 | 7,918 |
| Total per day | ........ | | 20½ | 1.145 | 13,885 |
| Total for one man | ........ | | 13 | .285 | 3,471 |

**Menu X.**—*For family equivalent to 4 men at moderate muscular work.*

| Food materials. | Weight. | | Cost. | Protein. | Fuel value. |
|---|---|---|---|---|---|
| *Breakfast.* | *Lbs.* | *Oz.* | *Cents.* | *Pounds.* | *Calories.* |
| Oatmeal | 0 | 6 | 2 | 0.059 | 697 |
| Skim milk, 1 pint | 1 | 0 | 1½ | .034 | 170 |
| Sugar | | 2 | ½ | ........ | 232 |
| Bread (homemade) | 1 | 0 | 3 | .095 | 1,205 |
| Sausage | | 10 | 6 | .080 | 1,358 |
| Butter (24 cents per pound) | | 1 | 1½ | ........ | 217 |
| Total | ........ | | 14½ | .268 | 3,879 |
| *Dinner.* | | | | | |
| Beef flank, stew | 2 | 6 | 15 | .430 | 2,988 |
| Potatoes (60 cents per bushel) | 3 | 0 | 3 | .054 | 975 |
| Cabbage | | 12 | 1 | .013 | 105 |
| Corn-meal pudding: | | | | | |
| Corn meal | | 4 | ½ | .022 | 414 |
| Skim milk, 1 quart | 2 | 0 | 3 | .068 | 340 |
| Molasses | | 12 | 1 | .020 | 987 |
| Total | ........ | | 22½ | .604 | 5,909 |
| *Supper.* | | | | | |
| Beef, warmed in gravy | 1 | 8 | 3 | .086 | 598 |
| Hot biscuit | 2 | 0 | 6 | .340 | 2,600 |
| Butter | | 2 | 3 | ........ | 434 |
| Milk, 1 quart | 2 | 0 | 6 | .033 | 325 |
| Total | ........ | | 18 | .259 | 3,957 |
| Total per day | ........ | | 55 | 1.134 | 3,645 |
| Total for one man | ........ | | 14 | .285 | 3,411 |

MENU XI.—*For family equivalent to 4 men at moderate muscular work.*

| Food materials. | Weight. | | Cost. | Protein. | Fuel value. |
|---|---|---|---|---|---|
| *Breakfast.* | *Lbs.* | *Oz.* | *Cents.* | *Pounds.* | *Calories.* |
| Beef liver | 1 | 0 | 6 | .216 | 685 |
| Hot biscuit | 1 | 8 | 4½ | .140 | 2,595 |
| Butter | | 2 | 3 | ........ | 434 |
| Milk, 1 quart | 2 | 0 | 6 | .033 | 325 |
| Coffee | ........ | | 2 | .010 | 410 |
| Total | ........ | | 21½ | .399 | 4,429 |
| *Dinner.* | | | | | |
| Beef brisket, boiled | 2 | 8 | 15 | .313 | 3,950 |
| Apple pie | 1 | 0 | 5 | .033 | 1,250 |
| Potatoes | 2 | 0 | 3 | .036 | 650 |
| Bread | | 8 | 1½ | .048 | 603 |
| Butter | | 1 | 1½ | ........ | 217 |
| Skim milk, 1 quart | 2 | 0 | 3 | .033 | 170 |
| Total | ........ | | 29 | .463 | 6,810 |
| *Supper.* | | | | | |
| Corn meal in mush or cake | 0 | 6 | 1 | 0.033 | 621 |
| Skim milk, 1 quart | 2 | 0 | 3 | .068 | 340 |
| Bacon | | 8 | 8 | .046 | 1,390 |
| Coffee | ........ | | 2 | .010 | 410 |
| Total | ........ | | 14 | .157 | 2,761 |
| Total per day | ........ | | 64½ | 1.019 | 14,030 |
| Total for one man | ........ | | 16 | .255 | 3,507 |

## DISCUSSION OF THE MENUS.

These menus attempt to give, as nearly as convenient, the range of food materials and the variety of combination which might be found in the average well-to-do household. Some of the menus are more varied and costly than others, and a few are given showing the effect of the use of more milk, and also how a diet might easily become one-sided. The quantities of the different foods used per meal will not, it is believed, be found out of proportion to each other, though of course they will not suit every family. The weights of all materials, oatmeal and other cereals, meat, vegetables, etc., are for these substances as purchased.

The calculations of the quantities of nutrients contained in the different foods is based upon the average percentage composition of these materials. Inasmuch as the fats and carbohydrates are used simply as fuel they are not shown in the menus, only the quantity of protein and the fuel value of the food being of interest.

The cost of the different food materials must of necessity be more or less of a varying quantity, depending upon the season of the year, the character of the markets, large or small, city or country, etc. Of the more important food materials the assumed price per pound is as follows: Beef loin, 18 to 25 cents; shoulder, 12 cents; round, 14 cents; chicken, 15 cents; mutton loin, 16 cents; lamb leg, 20 cents; bacon, 16 cents; sausage, 10 cents; milk, 3 cents (6 cents per quart); skim milk, 1½ cents (3 cents per quart); butter, 32 cents; che eggs, 16 cents (24 cents per dozen); flour and meal, 2½ to 3 cents; cereals, 5 to 8 cents; bread, 4 cents; potatoes and other vegetables, 1½ cents (90 cents per bushel); bananas, about 8 cents (20 cents per dozen); oranges, about 7 cents (25 to 40 cents per dozen); apples, 1½ cents per pound (90 cents per bushel).

It is probable that the above figures represent more nearly the average prices of the different food materials in the eastern part of the country than in the central and western portions, where meats, cereals and many other products are somewhat cheaper. It is also to be borne in mind that by observing the markets many food materials can be purchased much cheaper than here indicated, while on the other hand there may be times when they will be much more expensive. The choice of vegetables and fruits will naturally be governed by their abundance and cost.

Another point that must not be overlooked is that the quantities, and consequently the costs, here given are for four working men; that is to say, men engaged in moderately hard muscular labor. Of course, different individuals differ greatly in their needs for food. These figures express only general averages and are based upon the best information accessible.

When a dish is indicated that must be prepared at the home the proportions of nutrients entering therein are indicated, but not of condiments, flavorings, and other accessories. Thus, if lemon sauce is indicated with a pudding no mention is made of the lemon peel, which has little food value and is simply used for the flavor it imparts. Likewise amounts of vinegar are not indicated where salads are called for. The values given under the head "tea or coffee" are obtained by figuring the actual cost and nutrients of the ingredients entering the coffee. It is calculated that for four cups of coffee 2 ounces milk, 2 ounces cream, 2 ounces sugar, and 1½ ounces coffee may be used. These would cost about 3½ cents, and would furnish 0.010 pound of protein and a fuel value of 410 calories. The coffee or tea infusion itself contains no nutrients. In the menus it has been supposed that at times the persons would want but one cup of coffee each, while at times they would desire two cups, and occasionally allowance has been made for six cups for the four persons.

The weights of meats and vegetables given in the menus are for these articles as found in the market. The meats will include, as a rule, more or less bone and the vegetables skin, which is inedible and is rejected. In estimating the nutrients in these foods allowance is made for what has been found to be about an average proportion of bone in different cuts of meat. In vegetables it is supposed that from one-fifth to one-sixth will be thrown away in preparing these for the table. The weights of the cereals are for these in the dry condition before cooking. In cooking it is understood that flour, sugar, butter, milk, etc., are measured rather than weighed, and both the quantity by bulk l by weight are as a rule recorded in the menus. It is a very diffi- t matter to reduce teaspoonfuls and tablespoonfuls of materials to a nite weight, and even cupfuls are a very unsatisfactory measure. eneral the following averages have been taken for the weight of erent measures of different foods:

| | |
|---|---|
| cupful=one-half pint | =one-half pound of rice, cornstarch, sugar, milk, sirup, butter.<br>=six ounces of hominy, corn meal, buckwheat.<br>=one-fourth pound of flour, wheat breakfast foods, cerealine, oatmeal. |
| One tablespoonful | flour, cereals, etc.=about ½ ounce.<br>corn meal=about ¾ ounce.<br>butter, starch, rice, sugar, etc.=about 1 ounce. |

he weights of a cupful of the different foods may be considered as y accurate, but the estimated weight of one tablespoonful of rent materials is one of the crudest makeshifts, depending upon spoon, and especially upon what the person considers a spoonful.

n the menus given above only such an amount of each food mate- is indicated as may be completely consumed at each meal. No wance is made for material to be left over. Of course in the ordi- y household it is calculated that there will be a rather larger quan- of the different dishes prepared than will be consumed at one al. The food remaining is either wasted or warmed up in some of many ways with which the good cook is familiar.

he principal classes of food materials may be roughly grouped as ows as regards the proportion of protein to fuel value, beginning h those which have the largest proportion of protein and ending h those which contain little or no protein:

| | |
|---|---|
| ls containing a large amount protein as compared with e fuel value. | Fish; veal; lean beef, such as shank, shoulder, canned corned, round, neck, and chuck; skim milk. |
| ls containing a medium ount of protein. | Fowl; eggs; mutton leg and shoulder; beef, fatter cuts, such as rib, loin, rump, flank, and brisket; whole milk; beans and peas; mutton chuck and loin; cheese; lean pork; oatmeal and other breakfast foods; flour; bread, etc. |
| ls containing little or no otein. | Vegetables and fruit; fat pork; rice; tapioca; starch; butter and other fats and oils; sugar, sirups. |

n planning a well-balanced diet the following points must be sidered:

1) The use of any considerable amount of fat meat or starchy food uld be offset by the use of some material rich in protein. Thus, if st pork is to be eaten for dinner, veal, fish, or lean beef might well eaten for breakfast or supper or both. Bean soup furnishes a con- erable amount of protein, while bouillon, consommé, or tomato soup

are practically useless as a source of nutriment. Skim milk a nishes protein, with but very little accompanying fats and c drates to increase the fuel value.

(2) The use of lean meats or fish for all three meals would req use of such foods as rice, tapioca, or cornstarch pudding, consi quantities of sugar and butter, and more vegetables, in order to sufficient fuel value.

(3) Since flour, sugar, and butter or lard enter very largely i tries and desserts, the larger the quantities of these dishes that sumed the larger does the fuel value tend to become as compar the protein.

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FARMERS' BULLETIN No. 85.

# FISH AS FOOD.

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BY

**C. F. LANGWORTHY, Ph. D.,**
*Office of Experiment Stations.*

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# LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
*Washington, D. C., March 12, 1907.*

Sir: I have the honor to transmit herewith an article on fish as food, prepared by C. F. Langworthy, of this Office, in accordance with instructions given by the Director. In this bulletin the attempt has been made to provide a useful summary of data regarding the nutritive value of fish and its place in the diet. The article is largely based on the investigations of Prof. W. O. Atwater, chief of the nutrition investigations of the Office of Experiment Stations, on the chemical composition and nutritive values of food fishes and aquatic invertebrates, the results of which were published in the reports of the United States Fish Commission for 1880, 1883, and 1888. Other publications of the Fish Commission, as well as reports of the New Jersey Experiment Stations, have been consulted, material from other authoritative sources has been incorporated, and the practical applications of scientific investigations regarding the food value of fish have been pointed out and illustrated. In preparing the present edition considerable new material has been added; the statistics of the fishery industry have, in so far as possible, been brought up to date; the tables and menus have been revised to include the results of analyses and experiments which have accumulated since the bulletin was first published, and a few other changes have been made which seemed desirable.

The publication of this article as a Farmers' Bulletin is respectfully recommended.

Respectfully,

A. C. True,
*Director.*

Hon. James Wilson,
*Secretary of Agriculture.*

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# FISH AS FOOD.

## INTRODUCTION.

### VALUE AND USE OF FISH.

As ordinarily used, the term fish includes, besides the fish proper, many other water animals, as oysters, clams, and other mollusks; lobsters, crawfish, crabs, and shrimps, and turtle and terrapin. The term "sea food" is often used to cover the whole group, or, more particularly, salt-water food products as distinguished from those of fresh water.

Fish in one form or another is almost universally recognized as an important food material, and enters to some extent into the diet of very many if not the majority of American families. Few, however, have any adequate conception of the great importance of the fisheries of the United States and of the immense amount of nutritive material which is every year taken from the salt and fresh waters of this country.

From recent data collected by the United States Fish Commission it appears that more than 528,000,000 pounds of fish, crustaceans, etc., are annually taken from the waters of the New England States; over 819,000,000 pounds from the Middle Atlantic States; over 106,000,000 from the South Atlantic States; 113,000,000 from the Gulf States; 217,000,000 from the Pacific coast; 96,000,000 from the Mississippi River and its tributaries, and 166,000,000 pounds from Alaska. The products of the fisheries of the Great Lakes exceed 113,000,000 pounds annually, and of the minor interior waters 5,000,000 pounds. In addition, thousands of pounds of fish are annually caught by sportsmen, but statistics of the amount are not available. In the case of the coast sections the statistics given above include only the coast fisheries. The interior fisheries of Vermont are included with those of New England, the fisheries of New York and Pennsylvania on the Great Lakes with those of the Middle Atlantic States, and the fisheries of the east coast of Florida with those of the Gulf States. The data for the Great Lakes embrace only those States not having coast fisheries, but include the fisheries of the Ohio River for Ohio, Indiana, and Illinois. The figures for the interior States are confined to States not having coast or Great Lake fisheries. In all sections the data represent the products as they leave the hands of the fishermen, except that in the case of Alaska the figures include salmon after being canned or otherwise prepared for the market. In considering such products as clams, scallops, and oysters the weight of the edible portion only has been taken into account.

The total weight of the fish products of the United States as they leave the hands of the fishermen is about 2,169,000,000 pounds, representing in round numbers as the value of the catch $58,000,000. By the processes of canning, salting, smoking, and otherwise preserving the value of the fish is very much increased.

Of the very large quantity of fish annually placed on the American market, the greater part is consumed at home, although a portion is prepared in various ways for export.

The preference for fresh-water or salt-water fish is a matter of individual taste. Both are, so far as known, equally wholesome. Indeed, it may be said that in general the preference for one kind of sea food or another is quite largely a matter of circumstances. It is noticeable that many kinds of fish which are known to be good for food are seldom eaten. Among others may be mentioned the whiting, or silver hake, and the sea robin. The latter are taken in enormous quantities in certain regions. This prejudice against certain fish is largely local: for instance, skates are eaten on the western coast of the United States, but until recently they were regarded as of no value in the East. A few years ago sturgeon and eel were not generally eaten. To-day sturgeon is much prized, and in regions where it was formerly worthless commands a high price. Many persons have a prejudice against frogs' legs, while others consider them a great delicacy. In the United States they are now very commonly eaten, and frog raising for the market is more or less of an industry. It is doubtful if Americans ever eat any portion except the legs of frogs, yet in many regions of Europe the bodies are also used. In Cuba and other localities squid tentacles are eaten, and are undoubtedly palatable when well prepared. An interesting change of opinion regarding the use of a sea product may be noted in the case of abalone, a large mollusk abundant on the California coast, which was formerly disregarded as a food product by Americans, but which, it is said, owing to its use by the Chinese, has become known and is relished.

## CONDITIONS WHICH AFFECT THE MARKET VALUE OF FISH.

The market value of fish is affected by various conditions. Among these are the locality from which they come, the season in which they are taken, and the food on which they have grown. In general, it may be said that fish from clear, cold, or deep water are regarded as preferable to those from shallow or warm water, while fish taken in ters with a rocky or sandy bottom are preferable to those from ter with a muddy bottom. Some fish, for instance shad, are at their st during the spawning season, while others should not be eaten ring this period. Those fish which feed on small crustacea and the ter forms of animal and vegetable life, constituting their natural od, are preferable to those living upon sewage and other matter ich may contaminate the waters. (See p. 32.)

The mode of capture also affects the market value. Fish caught the gills and allowed to die in the water by slow degrees, as is the e where gill nets are used, undergo decomposition very readily and inferior for food. Fish are often landed alive and allowed to die wly. This custom is not only inhumane, but lessens the value of fish. It has been found that fish killed immediately after catching ain firm and bear shipment better than those allowed to die slowly. quality of the fish is often injured by improper handling in the ing boats before placing on the market. Improvements in trans- tation facilities and in other lines have made it possible to bring to market from distant fishing grounds in good condition.

resh-water and salt-water fish alike are offered for sale as taken m the water, and preserved in a number of ways. In some cases servation is only to insure transportation to remote points in good dition. Low temperature is the means most commonly employed this purpose. By taking advantage of the recent improvements apparatus and methods of chilling and freezing, fish may be pped long distances and kept a long time in good condition. Some the dangers from eating fish which is not in good condition are nted out on page 30.

The preservation of meat or fish by methods of cold storage has eloped very greatly within recent years and has grown to be a y important industry. The process depends for its success quite gely upon the fact that the activity of micro-organisms, which se putrefactive and other changes in food products, is lessened by d. In addition to micro-organisms which are almost inevitably sent, being found everywhere—in the air, in water, etc.—fish, like er meats, normally contain ferments which cause changes in com- sition and flavor comparable in some ways with those caused by cro-organisms, though they differ in important respects. From ent investigations along these lines, the conclusion was reached at when meat is stored at the freezing point of water (32° F.) the tivity of micro-organisms is checked, but the action of ferments rmally present in the meat still continues, and it ripens, though it es not decay. Such stored meat was regarded as especially suited r roasting or broiling, though not as good as fresh meat for boiling. n the other hand, the conclusion was reached that fish can not be satisfactorily preserved at 32° F., since this temperature is not sufficient to hinder the action of the ferments present in the fish flesh, though it checks the action of micro-organisms. The ferments acting upon the tissues in which they occur produce bodies of unpleasant flavor and the fish becomes unpalatable, though it is not in any sense decayed. To successfully hinder the action of the ferments a temperature lower than 32° F. is needed. These facts are in accord with the common practice of shipping fish frozen.

It is stated on good authority that in commercial practice 25° F. is regarded as the proper temperature for storing fish which has been previously frozen. For dried fish the proper temperature is 25° F., for fresh fish 25 to 30° F., for oysters 33 to 40° F., for oysters in the shell 40° F., and for oysters in the tub 35° F. Oysters should not be frozen. It is claimed that oysters may be safely kept for six weeks at a temperature of 40° F., and an instance is recorded in which they were kept ten weeks at this temperature for experimental purposes.

According to the practice of a successful firm dealing in frozen fish, the fish, as they are unloaded from the boats, are sorted and graded as to size and quality, then placed in galvanized iron pans about 2 feet long, covered with loosely fitting lids, and frozen by keeping them twenty-four hours at a temperature often as low as 16° below zero. The fish are removed from the pans in a solid cake and packed in tiers in the storehouse and marketed frozen. It is said that they may be thus preserved indefinitely, though as a rule frozen fish are only kept six to eight months, being frozen in the spring, when the supply is abundant, and sold in the winter or whenever fresh fish can not be readily obtained. Such frozen fish are commonly shipped in barrels packed with broken ice in such a manner that the water formed by the melting ice may readily escape.

The flavor of oysters is affected more or less by the locality in which they have grown, those from certain regions being regarded as of very superior quality. The season of the year affects the market value of oysters, although it is noticeable that as methods of transportation and preservation improve, the oyster season becomes longer. This may also be said of lobsters, crabs, etc. Extended investigations, including the conditions affecting the growth and food value of oysters, their parasites and diseases, etc., have been carried on by the New Jersey Experiment Stations. These investigations have shown that oysters rapidly deteriorate when removed from the water, through the fermentative action of bacteria; and that oysters in spawn deteriorate more rapidly than at any other season at the same temperature. However, oysters which are ready to spawn are considered especially palatable if cooked soon after removal from the sea bed.

## PREPARING FISH FOR MARKET.

ish are sold either "round," i. e., whole, or dressed. Sometimes
y the entrails are removed. Often, however, especially when
ssed for cooking, the head, fins, and, less frequently, the bones are
oved. This entails a considerable loss in weight as well as of
ritive material. It has been assumed that in dressing fish the fol-
ing percentages are lost: Large-mouthed black bass, sea bass, cisco,
gfish, mullet, white perch, pickerel, pike, tomcod, weakfish, and
tefish, each 17.5 per cent; small-mouthed black bass, eel, Spanish
kerel, porgy, and turbot, each, 13.5 per cent; butter-fish, 12.5 per
t; shad, 11 per cent; and brook trout, 16.5 per cent. More recent
ures for loss in weight in dressing are as follows: Bullhead, 50 per
t; buffalo-fish and lake sturgeon, 40 per cent; carp and sucker, 35
cent; fresh-water sheepshead, 23 per cent; grass pike, black bass,
ite bass, yellow perch, and salmon, 15 per cent, and eels, 10 per cent.

arge quantities of fish are dried, salted, and smoked, the processes
ng employed alone or in combination. These methods insure pres-
ation, but at the same time modify the flavor. Several fish prod-
s are also prepared by one or more of these processes. Caviar,
ich may be cited as an example, is usually prepared from sturgeon
by salting. The methods of salting and packing vary somewhat
give rise to a number of varieties. Although formerly prepared
ost exclusively in Russia, caviar is now made to a large extent in
United States. In methods of drying fish the Chinese are very
ert, producing, among other goods, dried oysters, which are said
e palatable and of good quality. Dried fish and fish products are
important in the diet of the Japanese.

hen fish are salted and cured there is a considerable loss in weight,
to removal of the entrails, drying, etc. Codfish lose 60 per cent
reparation for market. If the market-dried fish is boned there is
rther loss of 20 per cent. The loss in weight of pollock from the
nd to the market-dried fish is 60 per cent; haddock, 62 per cent;
e, 56 per cent; and cusk, 51 per cent.

he Scandinavians make a number of fish products in which the fish
llowed to ferment, the methods followed being in a way compar-
e with those employed in the manufacture of sauerkraut. In Java
natives are very partial to fish which has undergone fermentation,
etimes apparently putrefactive and resulting in a product which
uld be considered entirely unfit for food from a western standpoint.

he canning industry has been enormously developed in recent years
thousands of pounds of fish, oysters, lobsters, etc., are annually
served in this way. In canning, the fish or other material is heated
air being sometimes exhausted also) to destroy micro-organisms,

and sealed to prevent access of air, which would introduce micr organisms as well as oxygen. Thus the canned material is preserv from oxidation and decomposition. The processes of canning ha been much improved, so that the original flavor is largely retaine while the goods may be kept for an indefinite period. Fish, as we as meat, is usually canned in its own juice or cooked in some for though sardines and some other fishes are commonly preserved in oi

Various kinds of fish extract, clam juice, etc., are offered for sal These are similar in form to meat extract. There are also a numbe of fish pastes and similar products—anchovy paste, for instance—which are used as relishes or condiments.

Preservatives such as salicylate of soda are employed to some exten in marketing fish and especially oysters. The extended use of such materials is not desirable since some of them are justly regarded as harmful.

Oysters and other shellfish are placed on the market alive in the shell or are removed from the shell and kept in good condition by chilling or other means. Oysters in the shell are usually transported in barrels or sacks. Shipment is made to far inland points in refrigerator cars and to Europe in the cold-storage chambers of vessels. Large quantities of shellfish are also canned. Oysters are often sold as they are taken from the salt water. However, the practice of "freshening," "fattening," or "floating" is very widespread—that is, oysters are placed in fresh or brackish water for a short period. They become plump in appearance and have a different flavor from those taken directly from salt water (see p. 15). As noted on page 32, care should be taken that the oysters are grown and fattened in water which is not contaminated by sewage.

Lobsters, crabs, and other crustacea are usually sold alive. Sometimes they are boiled before they are placed on the market. Large quantities of lobsters, shrimps, and crabs are canned.

Turtle and terrapin are usually marketed alive. Turtle soup, however, is canned in large quantities. Frogs are marketed alive or dressed, and may be eaten at all seasons, but are in the best condition in the fall or winter. It is said that Minnesota is the center of the frog industry in the United States, the catch for a year being about 5,000,000 frogs, or not far from 500,000 dozen pairs of frogs' legs, the annual value of the frog business being upward of $100,000.

## NUTRITIVE VALUE OF FISH.

### COMPOSITION OF FISH.

Fish contain the same kinds of nutrients as other food materials. In general it may be said that food (fish, meat, cereals, vegetables, etc.) serves a twofold purpose: It supplies the body with material for build-ng and repairing its tissues and fluids, and furnishes it with fuel for maintaining body temperature and for supplying the energy necessary for muscular work.

In a way the body is like a machine, with food for its source of motive power. The body differs from a machine, however, in that the fuel, i. e., food, is used to build it as well as supply it with energy. Further, if the body is supplied with more food than is needed, the excess can be stored as reserve material, usually in the form of fat. In the furnace, fuel is burned quickly, yielding heat and certain chemical products—carbon dioxid, water vapor, and nitrogen. In the body the combustion takes place much more slowly, but in general the final products are the same. The combustion of nitrogen is, however, not so complete as in a furnace. Due allowance is made for this fact in calculations involving the question of the energy which food will furnish.

Food consists of an edible portion and refuse, i. e., bones of fish and meat, shells of oysters, bran of wheat, etc. Although foods are so different in appearance, chemical analysis shows that they are all made up of a comparatively small number of chemical compounds. These are water and the so-called nutrients, protein or nitrogenous materials, fat, carbohydrates, and ash or mineral matter. Familiar examples of protein are lean of fish and meat, white of egg, casein of milk (and cheese), and gluten of wheat. Fat is found in fat fish and meat, in lard, fat of milk (butter), and oils, such as olive oil. Starches, sugars, and woody fiber or cellulose form the bulk of the carbohydrates. Certain carbohydrates are found in meat and fish, although the amount is not large. The protein, fats, and carbohydrates are all organic substances—that is, they can be burned with the formation of various gases, chiefly carbon dioxid and water, leaving no solid residue. The mineral matters will not burn, and are left behind when organic matter is ignited. By analysis the nutrients have been found to be made up of a comparatively small number of chemical elements in varying combinations. These are nitrogen, carbon, oxygen, hydrogen, phosphorus, sulphur, calcium, magnesium, sodium, potassium, silicon, chlorin, fluorin, and iron. Doubtless no single nutrient contains all these elements. The body tissues and fluids contain nitrogen; and hence protein, which alone supplies nitrogen to the body, is a necessary factor in food. All the nutrients except mineral matter contain carbon, oxygen, and hydrogen, and can supply them to the body. Protein, fat, and carbohydrates are all sources of energy.

The value of a food as a source of material for building and repairing the body is shown by its chemical composition—that is, by the amount of digestible nutrients which it contains. Some other means are necessary to show its value as a source of energy. It is known that all energy may be measured in terms of heat. In order to have some measure for expressing the amount of heat the calorie is taken as a unit. Roughly speaking, this is the amount of heat required to raise the temperature of 1 pound of water 4° F. One pound of starch would, if burned and all the heat utilized, raise 1,900 pounds of water 4° in temperature; or it would raise 5 gallons of water from the freezing point to the boiling point, but would not cause it to boil.

The number of calories which different foods will supply may be determined by burning them in an apparatus called a calorimeter, or by taking the sum of the calories which it is calculated the protein, fat, and carbohydrates making up the food would furnish. It has been found by experiment that the fuel value of a pound of protein as ordinarily burned in the body is 1,860 calories; the fuel value of a pound of carbohydrates is the same, while that of a pound of fat is 2.25 times as great.

The value of a food is usually judged by several different standards. Thus it must be digestible and palatable, furnish the nutrients needed by the system in proper amounts, and be reasonably cheap.

The relative nutritive value of any food may be learned by comparing its composition and energy value with similar data for other foods. Table 1 shows the composition of a number of food fishes, fresh and preserved in a variety of ways; oysters, clams, and other mollusks; lobsters, shrimps, crawfish, and crabs; turtle and terrapin, and frogs' legs. For purposes of comparison the analyses of a number of kinds of meat, vegetables, and other common food materials, are included.

In several cases the analysis of fish, whole and dressed, is given. Usually the composition of the dressed fish was computed from that of whole fish with the aid of the figures for loss of weight in dressing for market, mentioned on page 7.

TABLE 1.—*Composition of fish, mollusks, crustaceans, etc*

| Kind of food material. | Refuse (bone, skin, etc.). | Salt. | Water. | Protein by factor (N× 6.25). | Fat. | Carbohydrates. | Ash or mineral matter. | Total nutrients. | Fuel value per pound. |
|---|---|---|---|---|---|---|---|---|---|
| FRESH FISH. | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Calories.* |
| Alewife, whole | 49.5 | ....... | 37.6 | 9.8 | 2.4 | ....... | 0.8 | 13.0 | 277 |
| Bass, large-mouthed black, dressed | 46.7 | ....... | 41.9 | 10.3 | .5 | ....... | .6 | 11.4 | 209 |
| Bass, large-mouthed black, whole | 56.0 | ....... | 34.6 | 8.5 | .4 | ....... | .5 | 9.4 | 172 |
| Bass, small-mouthed black, dressed | 46.4 | ....... | 40.1 | 11.7 | 1.3 | ....... | .7 | 13.7 | 268 |
| Bass, small-mouthed black, whole | 53.6 | ....... | 34.7 | 10.1 | 1.1 | ....... | .6 | 11.8 | 227 |
| Bass, sea, dressed | 46.8 | ....... | 42.2 | 10.5 | .2 | ....... | .7 | 11.4 | 200 |
| Bass, sea, whole | 56.1 | ....... | 34.8 | 8.7 | .2 | ....... | .6 | 9.5 | 165 |
| Bass, striped, dressed | 51.2 | ....... | 37.4 | 8.8 | 2.2 | ....... | .5 | 11.5 | 249 |
| Blackfish, dressed | 55.7 | ....... | 35.0 | 8.4 | .5 | ....... | .5 | 9.4 | 173 |
| Bluefish, dressed | 48.6 | ....... | 40.3 | 10.0 | .6 | ....... | .7 | 11.3 | 204 |
| Butterfish, dressed | 34.6 | ....... | 45.8 | 11.8 | 7.2 | ....... | .7 | 19.7 | 509 |
| Butterfish, whole | 42.8 | ....... | 40.1 | 10.3 | 6.3 | ....... | .6 | 17.2 | 440 |
| uropean analysis) | 37.1 | ....... | 48.4 | .......... | .7 | ....... | .9 | 14.5 | 263 |

TABLE 1.—*Composition of fish, mollusks, crustaceans, etc.*—Continued.

| food material. | Refuse (bone, skin, etc.). | Salt. | Water. | Protein by factor (N× 6.25). | Fat. | Carbohydrates. | Ash or mineral matter. | Total nutrients. | Fuel value per pound. |
|---|---|---|---|---|---|---|---|---|---|
| ISH—continued. | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Calories.* |
| d | 29.9 | ........ | 58.5 | 11.1 | 0.2 | ........ | 0.8 | 12.1 | 209 |
|  | 9.2 | ........ | 72.4 | 17.0 | .5 | ........ | 1.0 | 18.5 | 327 |
| ed | 40.3 | ........ | 49.0 | 10.1 | .1 | ........ | .5 | 10.7 | 186 |
| ater, dressed | 20.2 | ........ | 57.2 | 14.8 | 7.2 | ........ | .8 | 22.8 | 558 |
| common, dressed | 57.0 | ........ | 35.8 | 6.4 | .3 | ........ | .6 | 7.3 | 127 |
| winter, dressed | 56.2 | ........ | 37.0 | 6.3 | .2 | ........ | .5 | 7.0 | 122 |
| sed | 52.2 | ........ | 39.5 | 7.3 | .3 | ........ | .5 | 8.1 | 145 |
| dressed | 51.0 | ........ | 40.0 | 8.4 | .2 | ........ | .6 | 9.2 | 159 |
| ressed | 17.7 | ........ | 61.9 | 15.3 | 4.4 | ........ | .9 | 20.6 | 454 |
| hole | 42.6 | ........ | 41.7 | 11.2 | 3.9 | ........ | .9 | 16.0 | 363 |
| dressed | 40.7 | ........ | 43.7 | 11.6 | 3.5 | ........ | .7 | 15.8 | 354 |
| Spanish, dressed | 24.4 | ........ | 51.4 | 16.3 | 7.2 | ........ | 1.2 | 24.7 | 585 |
| Spanish, whole | 34.6 | ........ | 44.5 | 14.1 | 6.2 | ........ | 1.0 | 21.3 | 508 |
| ssed | 49.0 | ........ | 38.2 | 9.9 | 2.4 | ........ | .6 | 12.9 | 277 |
| ole | 57.9 | ........ | 31.5 | 8.2 | 2.0 | ........ | .5 | 8.9 | 231 |
| te, dressed | 54.6 | ........ | 34.4 | 8.8 | 1.8 | ........ | .5 | 11.1 | 231 |
| te, whole | 62.5 | ........ | 28.4 | 7.3 | 1.5 | ........ | .4 | 9.2 | 195 |
| ow, dressed | 35.1 | ........ | 50.7 | 12.8 | .7 | ........ | .9 | 14.4 | 259 |
| ressed | 35.9 | ........ | 51.2 | 12.0 | .2 | ........ | .7 | 12.9 | 227 |
| hole | 47.1 | ........ | 42.2 | 9.9 | .2 | ........ | .6 | 10.7 | 186 |
| essed | 28.5 | ........ | 54.3 | 15.4 | .6 | ........ | 1.1 | 17.1 | 304 |
| whole | 45.5 | ........ | 39.5 | 10.3 | 4.3 | ........ | .5 | 15.1 | 358 |
| sed | 58.7 | ........ | 34.6 | 8.6 | 2.4 | ........ | .7 | 11.7 | 254 |
| le | 60.0 | ........ | 29.9 | 7.4 | 2.1 | ........ | .6 | 10.1 | 218 |
| er, dressed | 55.9 | ........ | 35.0 | 8.5 | .2 | ........ | .5 | 9.2 | 163 |
| er, dressed | 45.3 | ........ | 43.7 | 10.6 | .3 | ........ | .7 | 11.6 | 204 |
| lifornia (sections) | 10.3 | ........ | 57.9 | 16.7 | 14.8 | ........ | .9 | 32.4 | 903 |
| aine, dressed | 23.8 | ........ | 51.2 | 15.0 | 9.5 | ........ | .9 | 25.4 | 658 |
| ed | 43.9 | ........ | 39.6 | 10.6 | 5.4 | ........ | .8 | 16.8 | 408 |
| le | 50.1 | ........ | 35.2 | 9.4 | 4.8 | ........ | .7 | 14.9 | 363 |
|  | ........ | ........ | 71.2 | 23.5 | 3.8 | ........ | 1.5 | 28.8 | 581 |
| le | 41.9 | ........ | 46.1 | 10.1 | 1.0 | ........ | 1.0 | 12.1 | 222 |
| dressed | 14.4 | ........ | 67.4 | 15.1 | 1.6 | ........ | 1.2 | 17.9 | 340 |
| ressed | 51.4 | ........ | 39.6 | 8.4 | .3 | ........ | .5 | 9.2 | 163 |
| hole | 59.9 | ........ | 32.7 | 6.9 | .2 | ........ | .4 | 7.5 | 132 |
| k, dressed | 37.9 | ........ | 48.4 | 11.9 | 1.3 | ........ | .7 | 13.9 | 268 |
| k, whole | 48.1 | ........ | 40.4 | 9.9 | 1.1 | ........ | .6 | 11.6 | 222 |
| , dressed | 37.5 | ........ | 44.4 | 11.0 | 6.2 | ........ | .7 | 17.9 | 449 |
| ssed | 39.5 | ........ | 43.1 | 8.9 | 8.7 | ........ | .8 | 18.4 | 513 |
| ole | 47.7 | ........ | 37.3 | 7.7 | 7.5 | ........ | .7 | 15.9 | 445 |
| dressed | 41.7 | ........ | 46.1 | 10.4 | 1.3 | ........ | .7 | 12.4 | 240 |
| whole | 51.9 | ........ | 38.0 | 8.6 | 1.1 | ........ | .6 | 10.3 | 200 |
| dressed | 43.6 | ........ | 39.4 | 12.8 | 3.6 | ........ | .9 | 17.3 | 376 |
| whole | 53.5 | ........ | 32.5 | 10.6 | 3.0 | ........ | .7 | 14.3 | 313 |
| erage of fresh fish | 41.6 | ........ | 44.6 | 10.9 | 2.4 | ........ | .7 | 14.0 | 295 |
| ERVED FISH. |  |  |  |  |  |  |  |  |  |
| No. 1, salted | 19.7 | 8.3 | 34.8 | 13.9 | 21.2 | ........ | 2.1 | 37.2 | 1,107 |
| and dried | 24.9 | 17.3 | 40.2 | 19.0 | .4 | ........ | 1.2 | 20.6 | 363 |
| ss codfish, salted | ........ | 21.5 | 54.4 | 26.3 | .3 | ........ | 1.7 | 28.3 | 490 |
|  | ........ | ........ | 38.1 | 30.0 | 19.7 | 7.6 | [a]4.6 | 61.9 | 1,479 |
| alted, smoked, | 44.4 | 6.5 | 19.2 | 20.5 | 8.8 | ........ | .9 | 30.2 | 726 |
| salted, smoked, | 32.2 | 1.4 | 49.2 | 15.8 | .1 | ........ | 1.0 | 16.9 | 290 |
| alted, smoked, | 7.0 | 12.0 | 46.0 | 19.3 | 14.0 | ........ | 1.9 | 35.2 | 916 |
| anned | 5.0 | ........ | 53.6 | 23.7 | 12.1 | ........ | 5.3 | 41.1 | 916 |
| nned | 14.2 | ........ | 56.8 | 19.5 | 7.5 | ........ | [a]2.0 | 29.0 | 658 |
| canned | ........ | 1.9 | 68.2 | 19.6 | 8.7 | ........ | 1.3 | 29.6 | 708 |
| alt, canned | 19.7 | 8.3 | 34.8 | 13.9 | 21.2 | ........ | 2.1 | 37.2 | 1,107 |
| ned | ........ | ........ | 72.7 | 21.7 | 4.1 | ........ | 1.7 | 27.5 | 558 |
| moked, cooked, | ........ | 5.6 | 68.7 | 22.3 | 2.3 | ........ | 1.6 | 26.2 | 499 |
| LLUSKS. |  |  |  |  |  |  |  |  |  |
| ids | ........ | ........ | 88.3 | 6.0 | 1.3 | 3.3 | 1.1 | 11.7 | 222 |
| shell | 81.4 | ........ | 16.1 | 1.2 | .2 | .7 | .4 | 2.5 | 41 |
| nned | ........ | ........ | 83.4 | 8.8 | 2.4 | 3.9 | 1.5 | 16.6 | 327 |
|  | ........ | ........ | 80.3 | 14.8 | .1 | 3.4 | 1.4 | 19.7 | 336 |
| , in shell | 41.9 | ........ | 49.9 | 5.0 | .6 | 1.1 | 1.5 | 8.2 | 136 |
| , canned | ........ | ........ | 84.5 | 9.0 | 1.3 | 2.9 | 2.3 | 15.5 | 258 |

[a] Including salt.

TABLE 1.—*Composition of fish, mollusks, crustaceans, etc.*—Continued.

| Kind of food material. | Refuse (bone, skin, etc.). | Salt. | Water. | Protein by factor (N× 6.25). | Fat. | Carbohydrates. | Ash or mineral matter. | Total nutrients. |
|---|---|---|---|---|---|---|---|---|
| MOLLUSKS—continued. | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* |
| Round clams, removed from shell | ........ | ....... | 80.8 | 10.6 | 1.1 | 5.2 | 2.3 | 19.2 |
| Round clams, in shell | 67.5 | ....... | 28.0 | 2.1 | .1 | 1.4 | .9 | 4.5 |
| Round clams, canned | ........ | ....... | 82.9 | 10.5 | .8 | 3.0 | 2.8 | 17.1 |
| Mussels | 46.7 | ....... | 44.9 | 4.6 | .6 | 2.2 | 1.0 | 8.4 |
| General average of mollusks (exclusive of canned) | 59.4 | ....... | 34.7 | 3.2 | .4 | 1.4 | .9 | 5.9 |
| CRUSTACEANS. | | | | | | | | |
| Lobster, in shell | 61.7 | ....... | 30.7 | 5.9 | .7 | .2 | .8 | 7.6 |
| Lobster, canned | ........ | ....... | 77.8 | 18.1 | 1.1 | .5 | 2.5 | 22.2 |
| Crawfish, in shell | 86.6 | ....... | 10.9 | 2.1 | .1 | .1 | .2 | 2.5 |
| Crabs, in shell | 52.4 | ....... | 36.7 | 7.9 | .9 | .6 | 1.5 | 10.9 |
| Crabs, canned | ........ | ....... | 80.0 | 15.8 | 1.5 | .7 | 2.0 | 20.0 |
| Shrimp, canned | ........ | ....... | 70.8 | 25.4 | 1.0 | .2 | 2.6 | 29.2 |
| Fresh abalone | ........ | ....... | 72.8 | 22.2 | .3 | 3.3 | 1.4 | 27.2 |
| Canned abalone, flesh | ........ | ....... | 73.2 | 21.7 | .1 | 3.7 | 1.3 | 26.8 |
| Canned abalone, liquid in can | ........ | ....... | 93.8 | 4.4 | .1 | .2 | 1.5 | 6.2 |
| Dried abalone | ........ | ....... | 39.7 | 36.0 | .5 | 20.9 | 2.9 | 60.3 |
| General average of crustaceans (exclusive of canned and dried) | 50.2 | ....... | 37.8 | 9.5 | .5 | 1.0 | 1.0 | 12.0 |
| TERRAPIN, TURTLE, ETC. | | | | | | | | |
| Terrapin, in shell | 75.4 | ....... | 18.3 | 5.2 | .9 | ....... | .2 | 6.3 |
| Green turtle, in shell | 76.0 | ....... | 19.2 | 4.7 | .1 | ....... | .3 | 5.1 |
| Average of turtle and terrapin | 75.6 | ....... | 18.8 | 4.9 | .5 | ....... | .3 | 5.7 |
| Frogs' legs | 32.0 | ....... | 56.9 | 10.5 | .1 | ....... | .7 | 11.3 |
| General average of fish, mollusks, crustaceans, etc. | 45.0 | ....... | 42.3 | 9.7 | 2.1 | .2 | .7 | 12.7 |
| OTHER ANIMAL FOODS. | | | | | | | | |
| Beef, side, medium fat | 17.4 | ....... | 49.4 | 14.8 | 18.1 | ....... | .7 | 33.6 |
| Veal, side | 22.6 | ....... | 55.2 | 15.6 | 6.3 | ....... | .8 | 22.7 |
| Mutton, side | 19.3 | ....... | 43.3 | 13.0 | 24.0 | ....... | .7 | 37.7 |
| Average of beef, veal, and mutton | 19.4 | ....... | 49.3 | 14.5 | 16.1 | ....... | .7 | 31.3 |
| Pork, side | 11.2 | ....... | 26.1 | 8.3 | 54.8 | ....... | .4 | 63.5 |
| Chicken | 25.9 | ....... | 47.1 | 13.7 | 12.3 | ....... | .7 | 26.7 |
| Turkey | 22.7 | ....... | 42.4 | 16.1 | 18.4 | ....... | .8 | 35.3 |
| Milk | ........ | ....... | 87.0 | 3.3 | 4.0 | 5.0 | .7 | 13.0 |
| VEGETABLE FOODS. | | | | | | | | |
| Wheat flour | ........ | ....... | 12.0 | 11.4 | 1.0 | 75.1 | .5 | 88.0 |
| Corn meal | ........ | ....... | 12.5 | 9.2 | 1.9 | 75.4 | 1.0 | 87.5 |
| Wheat bread (from patent flour) | ........ | ....... | 35.3 | 9.2 | 1.3 | 53.1 | 1.1 | 64.7 |
| Beans, dried | ........ | ....... | 12.6 | 22.5 | 1.8 | 59.6 | 3.5 | 87.4 |
| Potato | 20.0 | ....... | 62.6 | 1.8 | .1 | 14.7 | .8 | 17.4 |
| Cabbage | 15.0 | ....... | 77.7 | 1.4 | .2 | 4.8 | .9 | 7.3 |
| Corn, canned | ........ | ....... | 76.1 | 2.8 | 1.2 | 19.0 | .9 | 23.9 |
| Salad greens | ........ | ....... | 86.7 | 4.2 | .6 | 6.3 | 2.2 | 13.3 |
| Apples | 25.0 | ....... | 63.3 | .3 | .3 | 10.8 | .3 | 11.7 |
| Bananas | 35.0 | ....... | 48.9 | .8 | .4 | 14.3 | .6 | 16.1 |
| Strawberries | 5.0 | ....... | 85.9 | .9 | .6 | 7.0 | .6 | 9.1 |
| Sugar | ........ | ....... | ........ | .......... | ....... | 100.0 | ....... | 100.0 |

The above list includes the more important food fishes, water inve brates, etc. There are numbers of other fish which are eaten greater or less extent. In general it may be said their composi would be similar to that of the fishes included in the table.

In a number of cases cited in the table above more than one sp men was analyzed, although only the averages are given in the ta *In such* cases the samples showed more or less variation in total n nts, but the variation was due more especially to the fats. Thus the t in the flesh of seven specimens of shad ranged from 6.5 to 13.6 per nt; in fresh mackerel from 2.2 to 16.3 per cent, and in fresh halibut om 2.2 to 10.6 per cent. The protein and ash or mineral matter mained practically the same in all the specimens where the wide fat riation was noticeable, an increase of fat being accompanied by a crease of water.

An extended study of the chemical composition of fish was recently rried on at the zoological station at Naples by Lichtenfelt. It was und that the composition of the muscular tissue changes periodically ith age, nutrition, and reproduction. Under the influence of hunger e amount of water in the flesh is increased and the proportion of lids diminished. The richer the muscles in fat, the greater the loss compared with lean fish. The amount of protein is also diminished t only in salmon, but in other sorts of fish. The amount of insolu- e proteids is decreased while the proportion of soluble proteids may either increased or lowered according to circumstances. Muscular tivity in connection with hunger seems a condition especially suited induce an increase of soluble proteids in fish flesh.

It will be seen from the table that fish is essentially a nitrogenous d. In this it resembles meat. Neither fish nor meat is a source of bohydrates. Oysters and other shellfish contain some carbohydrates, t the foods which supply this group of nutrients most abundantly sugar and the cereal grains. The place of fish in the diet, if judged its composition, is therefore the same as that of meat—that is, it sup- ments cereals and other vegetables, the most of which, as wheat, rye, ize, rice, potatoes, etc., are deficient in protein, the chief nutrient in flesh of fish. As regards the relative nutritive value of meat and h, Atwater's conclusion, from a large number of investigations, was at the only considerable difference is in the proportion of water and t present, the flesh of the fish having water where meat has fat.

From the standpoint of both nutritive value and palatability fish, cording to a recent German investigator, is an important food prod- t and, as shown by his experiments, equal to beef as a source of ergy in the diet. It produces the same sensation of satiety and this rsists for as long a time. It was found that fish caused the excre- on of a smaller amount of uric acid than meat.

In general, it may be said that fish, meat, eggs, milk, etc., also cereals nd vegetable foods, all supply fat, the amount varying in the different materials. Fish usually contains less fat than is found in meat. There s, however, much difference in the fat content of the various kinds of ish. They may, indeed, be roughly divided into three classes: The first lass would include those containing over 5 per cent fat; the second, hose containing between 2 and 5 per cent, and the third, those containing less than 2 per cent. The first group would include such fish as salmon, shad, herring, Spanish mackerel, and butter-fish; the second, whitefish, mackerel, mullet, halibut, and porgy; the third, smelt, black bass, bluefish, white perch, weakfish, brook trout, hake, flounder, yellow perch, pike, pickerel, sea bass, cod, and haddock.

As regards nitrogenous constituents, fish flesh contains more gelatin-yielding material (collagen) and less extractive material (meat bases) than meat. As is well known, the characteristic red color of blood and muscular tissue is due to the presence of a substance called hemoglobin. The flesh and blood of fish contain less of this and allied coloring matters than meat, which accounts for the light color commonly observed in fish flesh. The flesh of some fishes, like salmon, has a decided color. It is not due, however, to hemoglobin, but to the presence of a special pigment.

The so-called nitrogenous extractives ("meat extract"), contained in small quantities in fish as in other animal foods, are doubtless useful in nutrition, although opinions have differed as to their real function. Recent investigations indicate very strongly that flesh extractives play an important part in stomach digestion, as they have been shown to induce an abundant flow of normal gastric juice. Many of the ordinary food materials possess this property also, but the flesh extractives seem to be especially suited to the purpose. They do not, it is true, furnish the body much food material, but they are nevertheless important if they normally help it to digest other foods.

With the exception of a few kinds which are preserved whole, preserved fish, as a rule, show a small percentage of refuse. The percentage of actual nutrients is much larger than in the corresponding fresh fish, owing to the removal of a large part of the refuse and more or less water. The gain in nutrients is mostly represented by protein, which is the most valuable nutrient.

Dried fish is richer in nutritive material, pound for pound, than fresh fish, since it has been concentrated by evaporation. It has been found that the average loss in weight in drying is about 30 per cent, or less than the average values for different kinds of meat. The loss in weight is chiefly due to the evaporation of water, though in some cases dried fish contains a little less ether extract than fresh fish.

When foods are cooked there is, generally speaking, a loss of weight owing to the evaporation of water, and in the ordinary methods of cooking fish and meat some nutritive material is lost also. In recent experiments it was found that the water in which fish was boiled contained 9 to 11 per cent of the total fish protein.

Canned fish, which is in effect cooked fish, compares favorably as regards composition with the fresh material. Generally speaking, the amount of refuse is small, since the portions commonly rejected in preparation for the table have been removed before canning.

The various kinds of shellfish resemble meat and food fishes in general composition. They contain, however, an appreciable amount of carbohydrates. Oysters are the most important of the shellfish, judging by the relative amount consumed. Speaking roughly, a quart of oysters contains on an average about the same quantity of actual nutritive substance as a quart of milk, or three-fourths of a pound of beef, or 2 pounds of fresh codfish, or a pound of bread; but, while the weight of actual nutriment in the different quantities of food materials named is very nearly the same, the kind is widely different. That of the lean meat or codfish consists mostly of protein, the substance whose principal function is to make or repair blood, muscle, tendon, bone, brain, and other nitrogenous tissues. That of bread contains considerable protein, but a much larger proportion of starch, with a little fat and other compounds which supply the body with heat and muscular power. The nutritive substance of oysters contains considerable protein and energy-yielding ingredients. Oysters come nearer to milk than almost any other common food material as regards both the amounts and the relative proportions of nutrients.

Apparently as the oyster grows older, at least up to a certain time, not only do the proportions of flesh and liquids increase more rapidly than the shells, but the proportion of nutrients in the edible portion increases also; that is to say, 100 pounds of young oysters in the shell appear to contain less of flesh and of liquids than 100 pounds of older ones, and when both have been shucked a pound of shell contents from the older oysters would contain more nutriment than a pound from the younger.

Considering the edible portion of the oyster, after it has been removed from the shell, the differences in different specimens are much greater than is commonly supposed. This is apparent when a comparison is made of either the flesh (meat) or liquids (liquor) of different specimens, or the whole edible portion, the meat (solids) and liquor together. The percentage of water in the edible portion of different specimens of oysters which were analyzed in experiments conducted for the U. S. Fish Commission varied from about 83.4 to 91.4 per cent, and averaged 87.3 per cent. This makes the amounts of "water-free substance," i. e., actually nutritive ingredients, vary from 16.6 to 8.6 and average 12.7 per cent of the whole weight of the edible portion (shell contents) of the animals. In other words, the nutritive material in a quart (about 2 pounds) of shell contents (solids) varied from 2.75 to 5.33 ounces.

With oysters, long clams, and round clams in the shell there is naturally a large percentage of waste, as the shell constitutes a large proportion of the total weight. The average of 34 specimens of oysters in the shell, for instance, shows only 2.3 per cent of actual nutrients. Clams and mussels show a somewhat higher percentage.

Where these various shellfish are purchased as "solids"—that is, removed from the shell—a comparatively high price is usually paid. Where they are purchased in the shell, there is a very large percentage of waste. The conclusion is therefore warranted that, from a pecuniary standpoint, they are not the most economical of foods for the consumer. On the other hand, they have a useful place in the diet in helping to supply the variety which is apparently needed to insure the best workings of the digestive system. Often flavor has a value which can not be estimated in dollars and cents.

As already explained, it is a common practice of oyster dealers, instead of selling the oysters in the condition in which they are taken from the beds in salt water, to place them for a time—forty-eight hours, more or less—in fresh or brackish water, in order, as the oystermen say, to "fatten" them, the operation being also called "floating" or "laying out." By this process the oyster acquires plumpness and rotundity, and its bulk and weight are so increased as materially to increase its selling value. The belief is common among oystermen that this "fattening" is due to actual gain of flesh and fat, and that the nutritive value of the oyster is increased by the process. They find that the oysters "fatten" much more quickly in fresh than in brackish water. Warmth is so favorable to the process that it is said to be sometimes found profitable to warm artificially the water in which the oysters are floated. Although oysters are generally floated in the shell, the same effect may be obtained by adding fresh water to the oysters after they have been taken out of the shell. Oysters lose much of their salty flavor in "floating," and it is a common experience of oystermen that if the "fattened" oysters are left too long on the floats they become "lean" again.

It does not seem probable that the oysters would secure food enough to make appreciable gain in weight in the short time in which they remain in the fresh or brackish water.

It is known that when a solution of salts is separated by a suitable membrane from water containing a lesser quantity of salts in solution that the passage of salts immediately begins from the concentrated to the dilute solution. This is practically the condition which exists when the oyster is transferred from salt to fresh or brackish water. The fleshy portions of the body which are inclosed in a membrane contain salts in solution. As long as the oyster stays in salt water the solution of salts within its body would naturally be in equilibrium with the water outside. When the oyster is brought into fresh or brackish water, i. e., into a more dilute solution, it might be expected that the salts in the more concentrated solution within the body would pass out and a larger amount of fresh water enter and produce such a distention as actually takes place during floating. Careful experiments have shown that this supposition is entirely correct—that is, the oysters actually gain in weight. This is due largely to the fact that they lose mineral matter and gain a considerable amount of water. At the same time there is a slight loss of nutrients. When in their natural condition oysters contain from one-eighth to one-fifth more nutritive material than when fattened. In the opinion of very many consumers the improvement in appearance and flavor due to the removal of the salts more than compensates for the loss in nutritive value. It seems also to be a matter of common opinion that oysters keep better when part of the salts has been removed by "floating." However, the experiments of the New Jersey Experiment Stations have shown that freshened oysters will not remain alive as long as those taken directly from salt water. Freshening increases very rapidly the rate of weakening and decay (the life period being reduced one-half).

Frequently oysters become more or less green in color. There is a widespread opinion that "greening" is injurious. The color has been attributed to disease, to parasites, and to the presence of copper.

Experiments have shown that quite commonly the green color of American oysters at least is due to the fact that they have fed on green plants of very simple structure which are sometimes found to be abundant in salt or brackish waters. The green coloring matter of the plants is dissolved by the oyster juices and colors the tissues. The opinion of those who have investigated the matter carefully is that such green color is harmless. It may be removed, if desired, by placing the live oysters for a time in water where the green plants are not abundant. In Europe similar green oysters, called "groenbarden" or "Marennes," are especially prized, and to meet the demand oysters are greened by placing them as soon as captured in sea water, where they are kept for months and fed on a species of seaweed which imparts the coloring matter to the gills.

From carefully conducted investigations it appears that in some cases green oysters owe their color to the presence of copper. Such oysters are not generally considered wholesome. Green oysters containing copper differ in appearance from those owing their green tint to vegetable coloring matter, being grass green and not dark green in color and having a verdigris-like slimy secretion on the folds of the mantle. It is said that after the addition of vinegar a steel fork stuck into such oysters becomes coated with copper and that if ammonia is added the oysters become dark blue.

As will be seen by the figures in the table above, fresh and canned abalone correspond quite closely to oyster and clam products similarly prepared. As shown by some tests carried on by Jaffa and Mendel, abalone flesh is especially rich in glycogen. This fact is also emphasized by the figures in the table above, especially those for dried abalone, which are quoted from unpublished analyses made by Jaffa at the California Experiment Station. Generally speaking, compared with other sea products, the abalone is a nutritious food. Its flavor is said, by those who are familiar with it, to be excellent. Large quantities of abalone are canned, the flesh being cut into pieces of suitable size. Abalone is also dried extensively, the canned and the dried products finding a ready market among the Chinese.

Lobsters, crabs, shrimps, and crawfish are shown by analysis to contain a fairly large percentage of nutrients, as is especially noticeable when the composition of the flesh alone is considered. They resemble the lean rather than the fat fish in composition. Lobsters and crabs are very much alike as regards the structure of the flesh, which in each case consists of coarse dense-walled fibers. Lobsters and similar foods are prized for their delicate flavor. Except in certain regions where they are very abundant and the cost correspondingly low, they must be regarded as delicacies rather than as staple articles of diet. This is, however, a condition entirely apart from their composition. Judged by this alone, they are valuable foods, and may profitably be employed to give variety to the diet.

Although the total amount of turtle and terrapin used in the United States is quite large, the quantity is small as compared with the consumption of such foods as fish proper and oysters. As shown by their composition, turtle and terrapin are nutritious foods, although, under existing conditions, they are expensive delicacies rather than staple and economical articles of diet.

The total amount of frogs consumed per year for food is considerable. As shown by analysis, frogs' legs contain a fairly high percentage of protein. Only the hind legs are commonly eaten. The meat on other portions of the body is edible, although the amount is small, and is eaten in some localities. The prejudice which formerly existed against frogs' legs as a food was doubtless based on their appearance or some similar reason, as they are known to be wholesome.

## COST OF PROTEIN AND ENERGY IN FISH AND OTHER FOOD MATERIALS.

As previously stated, the two functions of food are to furnish protein for building and repairing the body and to supply energy for heat and muscular work. Although fish and meats in general may be regarded as sources of protein, they nevertheless furnish considerable energy. Indeed, those containing an abundance of fat supply a large amount of energy—that is, have a high fuel value. If a food contains little protein or energy and is high in price, it is evident that it is really expensive. On the other hand, a food may be high in price but in reality be cheap, if it furnishes a large amount of protein or energy or both. Foods which supply an abundance of protein or energy or both at a reasonable price are evidently of the greatest importance from the standpoint of economy.

In Table 2 is shown how much a pound of protein, or 1,000 calo of energy, would cost when supplied by a number of kinds of fish other foods at certain prices, and also the amount of total food, p tein, and energy which 10 cents' worth of the fish and other f materials would furnish.

E 2.—*Comparative cost of protein and energy as furnished by a number of food materials, at certain prices.*

| Kind of food material. | Price per pound. | Cost of 1 pound protein. | Cost of 1,000 calories energy. | Amounts for 10 cents. | | |
|---|---|---|---|---|---|---|
| | | | | Total weight of food material. | Protein. | Energy. |
| | *Cents.* | *Dollars.* | *Cents.* | *Pounds.* | *Pound.* | *Calories.* |
| n, whole, fresh | 10 | 0.90 | 48 | 1.000 | 0.111 | 209 |
| n, steaks | 12 | .71 | 36 | .833 | .142 | 274 |
| h | 12 | 1.20 | 58 | .833 | .083 | 172 |
| t | 18 | 1.18 | 40 | .556 | .085 | 253 |
| n, salt | 7 | .44 | 23 | 1.429 | .229 | 437 |
| rel, salt | 10 | .61 | 10 | 1.000 | .163 | 998 |
| n, canned | 12 | .62 | 18 | .833 | .162 | 547 |
| s (solids, 30 cents quart) | 15 | 2.50 | 68 | .667 | .040 | 147 |
| s (solids, 60 cents quart) | 30 | 5.00 | 136 | .333 | .020 | 74 |
| r | 18 | 3.05 | 129 | .556 | .033 | 77 |
| irloin steak | 25 | 1.52 | 26 | .400 | .066 | 380 |
| irloin steak | 20 | 1.21 | 21 | .500 | .083 | 475 |
| ound | 14 | .74 | 16 | .714 | .136 | 615 |
| tew meat | 5 | .38 | 5 | 2.000 | .266 | 1,862 |
| ried, chipped | 25 | .95 | 33 | .400 | .106 | 308 |
| n chops, loin | 20 | 1.48 | 14 | .500 | .068 | 694 |
| n, leg | 22 | 1.46 | 25 | .454 | .069 | 394 |
| oast, loin | 12 | .90 | 10 | .833 | .112 | 1,016 |
| moked ham | 22 | 1.55 | 14 | .454 | .064 | 729 |
| 7 cents quart) | 3½ | 1.06 | 11 | 2.857 | .094 | 891 |
| 6 cents quart) | 3 | .91 | 10 | 3.333 | .110 | 1,040 |
| flour | 3 | .26 | 2 | 3.333 | .380 | 5,363 |
| neal | 2 | .22 | 1 | 5.000 | .460 | 8,055 |
| es (90 cents bushel) | 1½ | .83 | 5 | 6.667 | .120 | 2,020 |
| es (45 cents bushel) | ¾ | .42 | 2 | 13.333 | .240 | 4,040 |
| ge | 2½ | 1.79 | 21 | 4.000 | .056 | 484 |
| anned | 10 | 3.57 | 23 | 1.000 | .028 | 444 |
| | 1½ | 5.00 | 7 | 6.667 | .020 | 1,420 |
| as | 7 | 3.75 | 24 | 1.429 | .011 | 414 |
| erries | 7 | 7.78 | 42 | 1.429 | .013 | 240 |

the table the prices per pound have been selected from the best available. It is of course impossible to set any one price which represent the cost of these materials per pound in all sections of ountry and at all times of the year. It is probable that the prices n represent more nearly those found in the eastern part of the ed States than in the southern, central, and western sections, e some food materials are usually somewhat cheaper.

is to be noted that the cost of 1 pound of protein and 1,000 calo- of energy have no direct relation to each other. A pound of pro- would be sufficient for a workingman about four days, while 1,000 ies of energy would be less than one-third the amount required lay. By dividing the cost of 1 pound of protein by 4 and multi- ng the cost of 1,000 calories of energy by 3.5 results are obtained h show approximately the relative cost of the protein and energy ient for one day as furnished by the different food materials. it would take, in round numbers, 25 cents' worth of salt mackerel cents a pound to furnish one day's supply of protein, while the sponding energy would require 38 cents' worth. Seven cents' h of flour would furnish the protein and 5 cents' worth the energy ired for one day. It is of course understood that no one food rial could furnish the nutrients in their proper proportions for adults under ordinary conditions of health and activity. The valu expressed in the table simply show the relative value from a pecunia standpoint of the different foods as a source of protein on the one ha and of energy on the other.

It will be seen from the above table that at 25 cents a pound it wou take $1.52 worth of sirloin steak to furnish a pound of protein, whi the same amount could be obtained in 74 cents' worth of beef roun at 14 cents a pound, 71 cents' worth of cod steak at 12 cents a poun 44 cents' worth of salt cod at 7 cents a pound, or 26 cents' worth o wheat flour at 3 cents a pound. In like manner the cost of 1,000 calorie of energy would vary in these same food materials from 36 cents, a furnished by the cod steaks, to 2 cents as furnished by the flour.

It is evident that at the prices given the fruits are the most expe sive sources of protein, mollusks and crustaceans next, and the cheape meats and fish, with the cereals, the least expensive. As regard energy, on the other hand, mollusks and crustaceans are by far th most expensive sources, followed by fish and many kinds of meat, whi the cereals are the most economical.

## DIGESTIBILITY OF FISH.

The term digestibility, as commonly employed, has several signific tions. To many persons it conveys the idea that a particular foo agrees with the user. It is also very commonly understood to refe to ease or rapidity of digestion. One food is often said to be prefe able to another because it is more digestible—i. e., is digested in le time in the stomach, or is apparently digested more readily. A third meaning, and one which is usually understood in scientific treatises o such subjects, refers to the completeness of digestion. For insta two foods may have the same composition, but, owing to differen in mechanical condition or some other factor, one may be much mo completely digestible than the other—that is, give up more materia to the body in its passage through the intestinal tract.

The agreement or disagreement of a particular food with any pers in normal health is largely a matter of individual peculiarity. Whe foods habitually disagree with a person, and there is reason to belie that there is pronounced indigestion, the advice of a competent phy cian is needed, since the nourishment of an abnormal or diseased bod is a matter properly included under the practice of medicine.

In so far as ease or rapidity of digestion implies a saving of energ to the body, it may be a matter of importance, especially if the ener expenditure would otherwise be above the normal. However, little known concerning relative rapidity of digestion within the b Most of the current statements which refer to this are apparently bas on experiments carried on outside the body by methods of artificia digestion. Such experiments imitate as closely as possible the cond

ons in the body, but it is not at all certain that they are exactly the
me. Some experiments with man, which were made a good many
ars ago, before experimental methods had become fixed, are also
ten quoted, but it is only fair to say that the popular interpretation
the data recorded does not agree in many respects with that of
ained investigators.

The numerous artificial digestion experiments which have been made
ith fish indicate that it is less quickly digested than beef, being about
ual to lamb in this respect. However, as compared with other foods,
e difference in the digestibility of fish and meat, as shown by these
periments, is not very great. In some carefully conducted experi-
ents, which were reported only a few years ago by a German inves-
gator, it was noted that oysters, whitefish, and shellfish, taken in
derate amounts, left the stomach in two to three hours, in this
spect resembling eggs, milk, white bread, and some other foods.
viar left the stomach in three to four hours, as did also chicken,
n beef, boiled ham, beefsteak, coarse bread, etc. Salt herring left
stomach in four to five hours, other foods in the same class being
oked tongue, roast beef, roast goose, lentil porridge, and peas por-
ge. So far as fish is concerned, the general deduction from these
eriments was that it is more rapidly digested than meat. With
pect to its rapidity of digestion in the stomach, another German
estigator includes whitefish in the same class as the following animal
ds: Roast chicken, pigeon, roast veal, and cold underdone roast beef.
efore sweeping deductions are made the thoroughness with which
is digested should also be taken into account. A number of experi-
ts have been made with man to learn how thoroughly fish is digested
to compare it in this respect with other foods. In these experiments
food and feces were analyzed. Deducting the nutritive material
eted in the feces from the total amount consumed in the food showed
much was retained by the body. It was found that fish and lean
were about equally digestible. In each case about 95 per cent of
total dry matter, 97 per cent of the protein, and over 90 per cent of
fat were retained by the body. Other experiments of the same char-
r indicate that salt fish is less thoroughly digested than fresh fish.
t the Connecticut (Storrs) Station Milner studied the digestibility
fresh (canned) salmon, a typical fat fish, and fresh cod, a typical
fish, these materials each constituting a considerable part of a
ple mixed diet. The calculated coefficients of digestibility of the
non alone were protein 96.2 per cent and fat 97 per cent, while
6 per cent of the energy was available. In the case of the cod the
ues for protein and fat were 95.9 and 97.4 per cent, respectively, and
energy 80.3 per cent. It has been suggested that fat fish is less thor-
hly digested than lean fish, but in these experiments the two sorts
e digested on an average with practically the same thoroughness.
number of similar experiments have been made on the digestibility

of milk, eggs, bread, potatoes, and other animal and vegetable f
From a large amount of data of this sort some general dedu
have been drawn. Thus, it has been calculated that 97 per ce
the protein and 95 per cent of the fat of meats, fish, eggs,
products, and the animal food of a mixed diet are digested. Si
values are for the protein of cereals 85 per cent, for the fat 9
cent, and for the carbohydrates 98 per cent; for the protein, fat
carbohydrates of vegetables 83, 90, and 95 per cent, respectively
for the protein, fat, and carbohydrates of the total vegetable fo
a mixed diet 84, 90, and 97 per cent. From the available experi
data it also seems probable that leaner meats are more easily dig
than those containing more fat, and the leaner kinds of fish, such a
haddock, perch, pike, bluefish, etc., are more easily and readily dig
than the fatter kinds, as salmon, shad, and mackerel. Generally s
ing, it has been found that the protein of vegetable foods as serv
the table is less digestible than that of animal foods. For instance
fourth or more of the protein of potatoes and beans may escape d
tion and thus be useless for nourishment. This is perhaps entirely d
the mechanical condition in which the protein occurs in vegetable f
that is, it is often inclosed in cells which have hard walls and are not
upon by the digestive juices. It is ordinarily assumed that the
amount of carbohydrates in meat and fish is entirely digested. Carb
drates other than fiber, which make up the larger part of the vege
foods, are very digestible. The fat in both animal and vegetable
differs in digestibility under varying conditions. No marked diffe
in the digestibility of the fat in the two classes of food can be pointe

Persons differ in respect to the action of foods in the dige
apparatus; and fish, like other food materials, is subject to
influences of personal peculiarity.

The nutritive value of shellfish, as of other fish, depends to a
siderable extent upon its digestibility, but information on this po
so limited that but little can be said with certainty here. Perhap
most that can be said is that while there are people with whom
foods do not always agree, yet oysters belong to the more easily di
ible class of foods. In a recently published study of the compos
of the oyster and other problems connected with their food value
statement is made that the nutrients occur largely in forms in w
they are readily assimilated, as is shown by the fact that one-ha
the crushed oyster and one-fourth of the whole oyster is solub
water. So far as can be learned no experiments have been
which show how thoroughly clams, crabs, and other crustacea, tu
and terrapin, and frogs' legs are digested.

## PLACE OF FISH IN THE DIET.

The chief uses of fish as food are (1) to furnish an economical so
of nitrogenous nutrients and (2) to supply the demand for variet
the diet, which increases with the advance of civilization.

Inspection of a considerable number of dietary studies of families f farmers, mechanics, professional men, and others, carried on in different regions of the United States, shows that about 20 per cent of the total food, 43 per cent of the total protein, and 55 per cent of the total fat of the diet of the average family is obtained from meats, poultry, fish, shellfish, etc., together. Fish, shellfish, etc., alone furnish less than 3 per cent of the total food, less than 4 per cent of the total protein, and less than 1 per cent of the total fat, showing to what a limited extent such food is used in the average household. It is not improbable that in communities where fisheries constitute the principal industry much larger quantities are consumed. It has been found that the laborers employed in the fisheries in Russia consume from 26 to 62 ounces of fish daily. This, with some bread, millet meal, and tea, constitutes the diet throughout the fishing season. These quantities are unusually large, but no bad effects are mentioned as following the diet.

There is a widespread notion that fish contains large proportions of phosphorus, and on that account is particularly valuable as brain food. The percentages of phosphorus in specimens thus far analyzed are not larger than are found in the flesh of other animals used for food. But, even if the flesh be richer in phosphorus, there is no experimental evidence to warrant the assumption that fish is more valuable than meats or other food material for the nourishment of the brain.

The opinion of eminent physiologists is that phosphorus is no more essential to the brain than nitrogen, potassium, or any other element which occurs in its tissues. The value commonly attributed to the phosphorus is based on a popular misconception of statements by one of the early writers on such topics. In discussing the belief that "fish contains certain elements which are adapted in a special manner to renovate the brain and so to support mental labor" a prominent physiologist says, "There is no foundation whatever for this view."

It is well understood that persons in varying conditions of life and occupation require different kinds and quantities of food. For the laboring man doing heavy work the diet must contain a comparatively large amount of the fuel ingredients and enough of the flesh-forming substances to make good the wear and tear of the body. These materials are all present in the flesh of animals, but not in the requisite proportions. Fish and the leaner kinds of meat are deficient in materials which yield heat and muscular power. When, however, fish and meat are supplemented by bread, potatoes, etc., a diet is provided which will supply all the demands of the body. Where fish can be obtained at low cost it may advantageously furnish a considerable portion of the protein required, and under most conditions its use may be profitably extended solely on the plea of variety.

It should be stated that most physiologists regard fish a larly desirable food for persons of sedentary habits, because it seems to be less "hearty." While, so far as can be learned, such statements do not depend upon experimental evidence, they are thought to embody the result of experience.

### PREPARING FISH FOR THE TABLE.

Fish is prepared for the table in a variety of ways, which are described in detail in books devoted to cookery. A few words, however, may not be inappropriate on the general methods of cooking and possible loss of nutrients involved.

Fish is commonly boiled, steamed, broiled, fried, or baked, or may be combined with other materials in some made dish. When boiled, it is stated that the loss in weight ranges from 5 to 30 per cent. One experimenter gives 26 per cent as the average. This loss is largely made up of water—that is, the cooked fish is much less moist than the raw. Little fat or protein is lost. So far as known, experiments have not been made which show the losses by other methods of cooking. It is, however, probable that there would be usually a very considerable loss of water.

In most cases fat or carbohydrates in the form of butter, flour, or other material are added to fish when cooked, and thus the deficiency in fuel ingredients is made good. Boiled or steamed fish is often accompanied by a rich sauce, made from butter, eggs, etc. Fried fish is cooked in fat, and baked fish is often filled with force meat, and may also be accompanied by a sauce; the force meat being made of bread, butter, etc., contains fat and carbohydrates. In made dishes—chowders, fish pies, salads, etc.—fat and carbohydrates (butter, flour, vegetables, etc.) are combined with fish, the kind and amount varying in the individual cases. Furthermore, in the ordinary household, fish or meat is supplemented by such foods as bread, butter, potatoes, green vegetables, and fruit. That is, by adding materials in cooking and by serving other dishes with the cooked product the protein of the fish is supplemented by the necessary fat and carbohydrates.

### DAILY MENUS CONTAINING FISH.

By taking into account the chemical composition of a mixed diet and comparing it with accepted dietary standards it may be seen whether the diet is actually suited to the requirements of the body; that is, whether it supplies sufficient protein and energy and whether it supplies them in the right proportions.

A number of sample menus are given on pages 26 to 28, which show that the desired amounts of protein and energy may be readily supplied by a diet containing a considerable amount of fish. These menus (which are based in part on dietary studies and other food investiga-

of this Department covering a wide range and extending over
al years) are not intended as formulas for any family to follow,
imply as illustrations of the way in which menus containing the
er proportions of nutrients may be made up. The ingenuity of
ousewife and her knowledge of the tastes of the family will sug-
the special dishes and combinations suited to her needs. It is not
ned that any housewife will find it convenient to follow exactly
roportions suggested in the menus. The purpose is to show her
t what amounts and proportions of food materials would give the
red nutrients.

selecting these menus it has been the object to include such
nts of fish as might be commonly served in an ordinary house-
and not to provide meals with the largest possible quantity of
That the amount which it is possible to introduce in a single
may be large is shown by the "shore dinners" so common in
regions of New England, or by the famous dinners served at
nwich on the Thames, with six courses and fish in every course.

ith reference to the following menus several points should be
e in mind. The amounts given represent about what would be
l for in a family whose demand for food would be equivalent to
full-grown men at light to moderate manual labor, such as
inists, carpenters, mill workers, farmers, truckmen, etc., accord-
o the usually accepted dietary standards. It is ordinarily assumed
an average man in health performing light to moderate muscular
requires per day about 0.25 pound protein and 3,050 calories of
y, the latter being supplied in small part by protein, but mostly
t and carbohydrates. Men in professional life, performing less
ular work, require smaller amounts. The commonly accepted
ican dietary standard for such men calls for 0.22 pound protein
,700 calories of energy in the daily food. The amount of min-
natter required is not stated, since there is little accurate infor-
n available on this point. A diet made up of ordinary foods and
ying the necessary amounts of protein and energy would undoubt-
supply an abundance of mineral matter.

has been found that women and children consume somewhat less
than men. The assumption is usually made that, provided a
n is engaged in some moderately active occupation, she requires
t eight-tenths as much food as a man with a similar amount of
.

calculating the results of dietary studies (which may be most con-
ntly expressed in amounts for one man for one day), it is further
ned that a boy 13 to 14 years old and a girl 15 to 16 years old also
re about eight-tenths as much food as a man at moderately active
ular labor; a boy of 12 and a girl 13 to 14 years old, about seven-

tenths; a boy 10 to 11 and a girl 10 to 12 years old, about six-t
a child 6 to 9 years old, about five-tenths; one 2 to 5, about four-t
and an infant under 2 years, about three-tenths.

As previously stated, the quantities in the sample menus are fo
men at moderately active muscular work or an equivalent num
men, women, and children. A family might, for example, consi
mechanic and wife, with four children, two girls of 12 and 6 a
boys of 10 and 8 years, respectively. Here it would be assumed t
man would be engaged at moderately hard manual work. Acc
to the above factors, this family would be equal in food consumpti
men at moderate muscular exercise (1.0+0.8+0.6+0.6+0.5+0.
In the same way a day laborer's family, consisting of a father and m
with three children under 7 years of age, would be equivalent to
with moderate muscular exercise (1.0+0.8+0.5+0.4+0.3=3), and
require three-fourths the quantities indicated in the following m

Menu I.—*For family equivalent to four men at light to moderate muscular e*

| Food material. | Amount used. | | Protein. |
|---|---|---|---|
| BREAKFAST. | *Lbs.* | *oz.* | *Pound.* |
| Oranges | 2 | 0 | 0.012 |
| Omelet (8 eggs) | 1 | 0 | .131 |
| Butter for frying | 0 | 1 | .001 |
| Johnnycake[a] | 1 | 4 | .099 |
| Butter | 0 | 3 | .002 |
| Coffee | ..... | ..... | .008 |
| Total | ..... | ..... | .253 |
| DINNER. | | | |
| Boiled cod, fresh | 2 | 0 | .340 |
| Hollandaise sauce: | | | |
| Butter | 0 | 4 | .002 |
| Yolks of 2 eggs | 0 | 1¼ | .013 |
| Lemon juice, etc | ..... | ..... | ..... |
| Potatoes | 2 | 0 | .036 |
| Boiled rice[b] | 1 | 8 | .018 |
| Milk | 0 | 6 | .012 |
| Sugar | 0 | 3 | ..... |
| Bread | 0 | 12 | .069 |
| Butter | 0 | 3 | .002 |
| Total | ..... | ..... | .492 |
| SUPPER. | | | |
| Scalloped oysters: | | | |
| Oysters | 2 | 0 | .120 |
| Crackers | 0 | 4 | .027 |
| Butter | 0 | 2 | .003 |
| Milk | 0 | 4 | .008 |
| French fried potatoes | 1 | 0 | .018 |
| Lard | 0 | 2 | ..... |
| Bread | 0 | 8 | .046 |
| Butter | 0 | 2 | ..... |
| Sliced bananas | 1 | 0 | .009 |
| Sugar | 0 | 3 | ..... |
| Tea | ..... | ..... | .006 |
| Total | ..... | ..... | .237 |
| Total per day | ..... | ..... | .982 |
| Total for one man | ..... | ..... | .246 |

[a] Composition of cooked material from U. S. Dept. Agr., Office of Experiment Statio
revised.

[b] Composition of cooked material from unpublished data.

**Menu II.**—*For family equivalent to four men at light to moderate muscular work.*

| Food material. | Amount used. | | Protein. | Fuel value. |
|---|---|---|---|---|
| BREAKFAST. | | | | |
| Codfish creamed: | *Lbs.* | *oz.* | *Pounds.* | *Calories.* |
| Salt cod | 0 | 8 | 0.080 | 158 |
| Milk | 1 | 0 | .033 | 312 |
| Butter | 0 | 1 | .001 | 216 |
| Flour | 0 | 1 | .007 | 101 |
| Baked potatoes[a] | 1 | 12 | .044 | 721 |
| Bread | 0 | 12 | .069 | 887 |
| Butter | 0 | 4 | .002 | 863 |
| Coffee | | | .008 | 248 |
| Total | | | .244 | 3,501 |
| DINNER. | | | | |
| Clam soup: | | | | |
| Clams, round | 0 | 12 | .049 | 158 |
| Milk | 1 | 12 | .057 | 545 |
| Butter | 0 | 1½ | .001 | 324 |
| Flour | 0 | 1 | .007 | 101 |
| Onion, salt, pepper, etc | | | | |
| Roast lamb, leg[b] | 1 | 8 | .238 | 1,256 |
| Green peas[c] | 1 | 8 | .054 | 377 |
| Butter | 0 | 2 | .001 | 431 |
| Mashed potatoes[a] | 1 | 8 | .039 | 737 |
| Bread | 0 | 6 | .034 | 444 |
| Butter | 0 | 1 | .001 | 216 |
| Apple tapioca pudding | 1 | 0 | .003 | 541 |
| Total | | | .484 | 5,130 |
| SUPPER. | | | | |
| Lobster salad: | | | | |
| Lobster meat | 1 | 0 | .164 | 377 |
| Yolks of 3 eggs | 0 | 2 | .020 | 202 |
| Butter or oil | 0 | 3 | .002 | 647 |
| Milk | 0 | 7 | .014 | 187 |
| Sugar | 0 | 1 | | 113 |
| (Vinegar, salt, pepper, mustard) | | | | |
| Biscuit | 0 | 12 | .065 | 950 |
| Butter | 0 | 4 | .003 | 863 |
| Tea | | | .008 | 248 |
| Total | | | .276 | 3,537 |
| Total per day | | | 1.004 | 12,168 |
| Total for one man | | | .251 | 3,042 |

[a] Composition of cooked material from U. S. Dept. Agr., Office of Experiment Stations Bul. 28, revised.

[b] A larger piece would ordinarily be cooked. The amount given is for one meal.

[c] Weight with pods.

**Menu III.**—*For family equivalent to four men at light to moderate muscular work.*

| Food material. | Amount used. | | Protein. | Fuel value. |
|---|---|---|---|---|
| BREAKFAST. | | | | |
| Breakfast cereal: | *Lbs.* | *oz.* | *Pounds.* | *Calories.* |
| Cracked crushed wheat | 0 | 4 | 0.028 | 410 |
| Milk | 0 | 6 | .012 | 117 |
| Sugar | 0 | 2 | | 227 |
| Creamed dried beef: | | | | |
| Dried beef | 0 | 12 | .198 | 568 |
| Milk | 0 | 8 | .017 | 156 |
| Butter | 0 | 1 | .001 | 216 |
| French fried potatoes | 1 | 0 | .018 | 308 |
| Butter (taken up in frying) | 0 | 2 | .001 | 431 |
| Bread | 0 | 12 | .069 | 887 |
| Butter | 0 | 3 | .002 | 647 |
| Coffee | | | .008 | 248 |
| Total | | | .354 | 4,2[illegible] |

Menu III.—*For family equivalent to four men at light to moderate muscular work*

| Food material. | Amount used. | | Protein. |
|---|---|---|---|
| DINNER. | *Lbs.* | *oz.* | *Pounds.* |
| Halibut steak | 1 | 12 | 0.268 |
| Mashed potatoes[a] | 2 | 0 | .052 |
| Tomatoes (or half amount of parsnips) | 2 | 0 | .018 |
| Bread | 0 | 12 | .069 |
| Butter | 0 | 3 | .003 |
| Apple pie | 1 | 0 | .031 |
| Total | ........ | | .441 |
| SUPPER. | | | |
| Salmon croquettes: | | | |
| Canned salmon[a] | 0 | 8 | .098 |
| Mashed potatoes[b] | 1 | 0 | .026 |
| Butter | 0 | 1 | .001 |
| 1 egg | 0 | 2 | .016 |
| Prune sauce[b] | 1 | 0 | .005 |
| Muffins | 0 | 12 | .065 |
| Butter | 0 | 3 | .002 |
| Tea | ........ | | .008 |
| Total | ........ | | .221 |
| Total per pay | ........ | | 1.016 |
| Total for one man | ........ | | .254 |

[a] Composition of cooked material from U. S. Dept. Agr., Office of Experiment Stations Bul. 28,

[b] Composition of cooked material from unpublished data.

Menu IV.—*For family equivalent to four men at light to moderate muscular work.*

| Food material. | Amount used. | | Protein. |
|---|---|---|---|
| BREAKFAST. | *Lbs.* | *oz.* | *Pound.* |
| Breakfast cereal: | | | |
| Cracked crushed wheat | 0 | 4 | 0.028 |
| Milk | 0 | 6 | .012 |
| Sugar | 0 | 2 | ........ |
| Broiled salt mackerel | 1 | 6 | .191 |
| Boiled potatoes | 1 | 0 | .018 |
| Hot rolls | 0 | 12 | .067 |
| Butter | 0 | 3 | .002 |
| Coffee | ........ | | .008 |
| Total | ........ | | .326 |

The weights of fish, meats, and vegetables given in the menus are for ese articles as found in the market. The fish and meats will include, a rule, more or less bone, and the vegetables considerable skin and her parts, which are inedible and are rejected. In estimating the itrients allowance is made for what has been found to be the average roportion of bone in different cuts of meats. In vegetables it is sumed that from one-sixth to one-fifth will be rejected in preparing iem for the table. The weights of the breakfast cereals are for these the dry condition before cooking.

The values given for tea or coffee are obtained by taking account of ie sugar and milk or cream consumed with them. The infusion of tea coffee contains little, if any, nutritive material. The value of tea id coffee in the diet depends upon their agreeable flavor and mild imulating properties.

The calculations of the quantities of nutrients contained in the differ-it foods are based upon the average percentage composition of these aterials, some of the data being included in the table of composition page 10, and the remainder in a previous publication of this Office.[a]

The fats and carbohydrates in the different food materials are not own in the menus, since the quantity of protein and the fuel value the food are the values which are of special interest. The fuel ue of the fats and carbohydrates is, of course, included in the figures fuel value given.

In the menus only such an amount of each food is indicated as might completely consumed at each meal. Of course, in the ordinary usehold usually a rather larger quantity of the different dishes will prepared than will be consumed at one meal, but the thrifty house-per will see to it that what is not used at one meal will be utilized another.

It is not expected that each meal or the total food of each individual y will have just the amounts of protein and fuel ingredients that ake a well-balanced diet. The body is continually storing nutritive aterials and using them. It is a repository of nutriment which is ing constantly drawn upon and as constantly resupplied. It is not pendent any day upon the food eaten that particular day. Hence excess one day may be made up by a deficiency the next or vice rsa. Healthful nourishment requires simply that the nutrients as a ole during longer or shorter periods should be fitted to the actual eds of the body.

It will be seen that in each of the menus suggested fish occurs in at st two meals. However, in no case is the amount greater than expence has shown may commonly occur in actual dietaries. It is not intention to suggest that a diet containing such quantities of fish

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[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 28, revised.

be followed every day, but rather to show that fish may be r
combined with other food materials to supply the protein and e
required. While it may profitably be used more frequently in
families than is at present the case, the quantity used is a matte
settled by the demands of individual taste.

The menus attempt to cover, as regards fish and other mate
range in variety and combination such as might be found in an a
well-to-do household. Other dishes, such as fish soups, chowde
salads, etc., might have been included also, and would naturally
place on the table of a family fond of fish and fish products. In
ual preferences vary so much that no combination which co
selected would meet them all.

Nothing has been said of the cost of the food used in the n
All foods vary in price in different localities, and this is especial
case with fish. In general it may be said that a large variety of
green vegetables, etc., if it is necessary to purchase them, increas
cost of a diet out of proportion to the nutritive material furn
Such foods, however, are valuable, since they possess agreeable
and so render the diet appetizing. It is also generally believe
the acids, salts, and similar materials in fruits and vegetables a
value in maintaining the body in health. The income of the
chaser should determine how varied the diet may be.

## POSSIBLE DANGERS FROM EATING FISH.

In view of statements of a popular nature which have been mad
the dangers from eating poisonous fish or from ptomaines contain
fish, a few words summarizing the actual knowledge on these to
seem desirable.

There are several species of fish which are actually poisonous. F
of them, however, are found in the United States, and the chance
their being offered for sale are very small. Such fish are mostly c
fined to tropical waters.

Fish may contain parasites, some of which are injurious to m
These are, however, destroyed by the thorough cooking to which
is usually subjected.

Ptomaines are poisonous bodies due to the action of micro-organis
They are chemical compounds of definite composition and are el
rated by micro-organisms breaking down the complex ingredients
animal tissues, just as alcohol is due to the action of yeasts break
down sugar, or as acetic acid is formed from the alcohol of cider
wine by the yeast-like plant which produces vinegar, and which
call mother when we find it collected in masses. The formation
ptomaines quite generally, although not always, accompanies pu
faction (being greatest, it is said, in its early stages), and theref

reat care should be taken to eat fish only when it is in perfectly good ndition. Fish which has been frozen and, after thawing, kept for time before it is cooked, is especially likely to contain injurious tomaines.

Decomposition can often be recognized by the odor of the fish, pecially when it has progressed to any considerable extent. There re laboratory tests for showing decomposition at various stages and r indicating the presence of ptomaines.

In general it may be said that fish should be considered unfit for food hen the eyes have lost their sheen, the cornea is somewhat cloudy, the lls pale red, when blubber shows at the gills, when the scales are dry easily loosened, or when the meat is so soft that if pressed with the ger the indentation remains. Laying fish in water has been recom- ended as a means of judging of their condition. Those which sink ay be considered undecomposed and wholesome, while those which e decomposing will float.

Canned fish should never be allowed to remain long in the can after ening, but should be used at once. There is some possibility of dan- r from the combined action of the can contents and oxygen of the air on the lead of the solder or the can itself. Furthermore, canned h seems peculiarly suited to the growth of micro-organisms when posed to the air.

Finally, fish offered for sale should be handled in a cleanly manner, d stored and exposed for sale under hygienic conditions.

A kind of poisoning called mytilism, usually very fatal in its results, s been sometimes observed to follow the eating of clams. The ason for this illness is not definitely known, though it is attrib- ed to a poisonous body sometimes found in clams, especially in e liver. Just why this poisonous body occurs is not known, but is probably due to a disease or some abnormal condition; further- re, it has been noted that clams from some regions are quite uni- rmly poisonous. It is said that poisonous clams are less pigmented ghter with radiate streaks) than wholesome clams, which are uni- rmly darkly pigmented, and that the shells of the unwholesome clams e more friable and broader, and that the liver is larger, softer, and her in pigment and fat. A well-known writer on the subject recom- ends that the public should be warned against buying dead clams—at is, those which do not close the shell when taken out of the water—d that as a further precaution the liver and the broth should not be ten, if cases of mytilism have recently occurred locally or there is y other reason to suspect the clam supply.

Slight or serious poisoning has also been known to follow the eating oysters, though fortunately American oysters have been seldom

found to be a cause of such illness. As in the case of clams, th
for such illness is not definitely known, but it is probably du
occasional presence in oysters of some poisonous body due to
or a similar cause. An European investigator reached the co
that oysters are generally diseased in the summer months, tho
nature of the disease was not learned. He found that the
oysters possessed a characteristic milky appearance and that t
was much enlarged, gray, and soft. It does not seem probab
American oysters are generally diseased during the summer
as many who live in the oyster-producing regions eat them thro
the year, yet in view of the fact that bad results from eating s
are more frequently noticed in the summer than in the cooler m
possibly because they spoil more readily, omitting them from the
fare during the summer seems a wise precaution. Oysters dea
shell or those which are decomposed should under no circum
be eaten. When removed from the water good oysters close th
move when touched, are of normal size and color, and have
fluid inside the shell. In the case of oysters dead when take
the water, the shells remain open, while those which are decom
are discolored and very soft, have a stale odor, and show a b
ring on the inside of the shell.

Oyster beds should be free from sewage pollution, and
when "floated" or "fattened" should never be placed in wat
taminated by sewage. Severe illness and death have resulted i
cases from eating raw oysters contaminated with sewage con
typhoid fever germs.

It is only just to say that the dangers from parasites, micro-
isms, ptomaines, and uncleanly surroundings are not limited
Under conditions which favor the growth of the micro-organism
and other highly nitrogenous animal foods undergo decomp
resulting in the formation of ptomaines. Animal parasites
acquired from flesh of various kinds if not thoroughly cooke
vided, of course, the flesh is infested. This danger is reduced by
inspection. Vegetable foods also may become contaminated
ous ways. The importance of measures to secure pure and wh
food can hardly be overstated. The best interests of the
undoubtedly demand a strict and impartial supervision by pub
cers of the sale of food products.

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FARMERS' BULLETIN No. 86.

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# HIRTY POISONOUS PLANTS

OF

# THE UNITED STATES.

BY

V. K. CHESNUT,
Assistant Botanist, U. S. Department of Agriculture.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1898.

# LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Botan
*Washington, D. C., October 31,*

Sir: I have the honor to submit herewith for publication as a Farmers' B
manuscript by Mr. V. K. Chesnut, assistant botanist, entitled Thirty P
Plants of the United States. In July, 1898, the Division of Botany issued as
No. 20 a report by Mr. Chesnut entitled Principal Poisonous Plants of the
States. The publication of that bulletin, however, instead of satisfying the
for information on poisonous plants has increased it, and in order to supply t
merable requests received since its appearance, it has seemed desirable to r
the information which it contained, in a condensed, less expensive, and more
form. In the present publication several of the less important poisonous pla
been stricken out, while only a small amount of new matter has been added.
iological, botanical, and chemical technicalities have been omitted, as well
of the matter relating to remedies. The omission of remedies has been du
difficulty of imparting exact knowledge of this subject in sufficiently condens
and especially to a desire to avoid the danger involved in the application,
perienced persons, of remedies which themselves might be fatally poisonous if
erly used. Only under the most desperate circumstances should such rem
administered by anyone except a physician.

Respectfully,
Frederick V. Coville, *Bo*

Hon. James Wilson, *Secretary*.

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# THIRTY POISONOUS PLANTS OF THE UNITED STATES.

## INTRODUCTION.

In view of the frequent complaints made by farmers and others against various plants as poisonous to man and to animals, it is surprising that no illustrated account has been published of our harmful native species in such form as to be readily accessible to those who are most likely to suffer from their effects.

Statistics in regard to poisonous plants are lacking on account of a general ignorance of the subject, and it is therefore impossible to form even an approximate estimate of the amount of damage done by them. The various species of water hemlock (Cicuta) kill a number of children each year. In the State of New Jersey two quadruple cases of water-hemlock poisoning were reported during the spring of 1896, which resulted fatally to two of the eight individuals affected. The number of cattle killed by one species of Cicuta in Oregon alone is estimated to be over 100 per annum. The damage caused by the well-known loco weed in Colorado was so large that the State paid out nearly $200,000 in bounties in an effort, unfortunately ineffectual, to exterminate the pest. The distress caused by poison ivy is being constantly experienced by thousands of individuals.

The Division of Botany has for the last three years been collecting general and specific information concerning poisonous plants, both from general works and special articles and by experimental investigation. From a more recent date investigations have been made of cases of poisoning which have been reported in the newspapers or by the regular correspondents and friends of the Division. By communicating with the physicians who had charge of each case, accurate and full data were obtained with regard to many plants.

All poisonous plants are not equally injurious to all persons, nor to all forms of life. The most familiar illustration of this fact is to be found in the action of poison ivy. It has no apparent external effect upon animals, and a few of them, such as the horse, mule, and goat, eat its leaves with impunity. It acts upon the skins of a majority of persons, but with varying intensity. Many people are probably wholly immune, but some lose their resistant power in middle life; others have been known to attain immunity from it to a very considerable degree. There is a similar variability in the effects of poisonous plants taken internally. The qualifications involved in the definition of a poisonous plant are numerous, and can not well be introduced into this report. It may suffice here to say that death in some cases is attributable not to any poison which the plant contains, but to immoderate or incautious eating, or to mechanical injury, such as is produced in horses by the hairs of crimson clover, which under certain conditions accumulate in large balls and obstruct the intestines, or to the effect of parasitic growths, such as ergot occurring on rye. Neither the clover nor the rye is poisonous.

Excluding all that operate in these ways, there is still a large number of poisonous plants which, on account of their limited area of growth, and sometimes of the uncertainty of our knowledge concerning their evil effects, are comparatively little known. In the present bulletin, however, it is possible to consider only those which are well known to be poisonous.

## FLY AMANITA.

*Amanita muscaria* (L.) Fr.

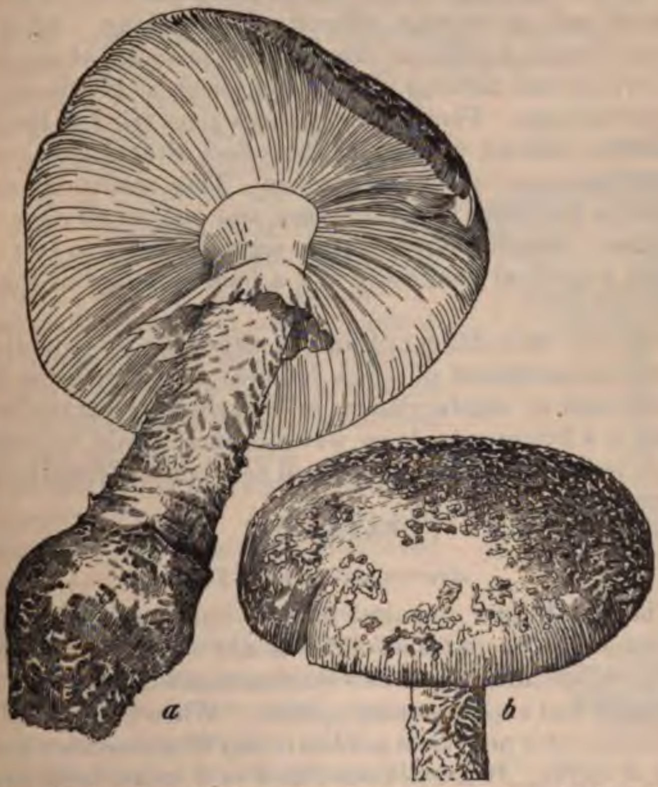
**Other names:** Fly fungus; fly agaric; fly killer; deadly amanita; false orange amanita. (Fig. 1.)

**Description.**—The amanitas form the most typical genus of that group of fleshy fungi which bear radiating plates or gills on the under surface of the cap. In the early stages of growth the amanitas are egg-shaped and are entirely enveloped by a white fleecy or cobwebby covering, which is ruptured as the stem lengthens. In a few species this covering adheres in loose, corky patches to the top of the cap, as seen in fig. 1, but sometimes it slips away from the cap entirely and forms a more or less continuous sheathing cup at the base of the stem, as shown in fig. 2. This fleecy covering and the invariably bulbous base of the stem are the most important characteristics of the genus, while the varying appearance of the former after rupture helps to distinguish the species. These features are well pronounced as a rule, but sometimes it requires some searching to find the cup.

Besides the general envelope there is also a secondary one, which at first covers the gills, extending from the stem outward in all directions horizontally to the rim of the cap. This breaks away from the cap before maturity and frequently forms a conspicuous collar about the upper part of the stem. The spores, and usually the gills also, are white.

The fly amanita is a handsome, robust species, 4 to 16 inches high. It is singularly free from larval pests and the usual signs of decay, and is highly attractive in appearance, taste, and smell. In its early stages the shape of the cap is very strongly convex, but by gradual expansion it becomes flat and even concave. It is invariably warty.

or it varies from nearly white through all shades of yellow to a red. As a rule, it is more reddish in the center and light yellow rd, but sometimes the color is uniform throughout. The ed base is marked with short, stubby projections of the skin, are generally replaced upward along the lower part of the by soft, flexible shavings, as seen in the figure. The general of the plant is very much like that of the orange amanita *nita caesarea*), but it differs conspicuously in the absence of a nd in the possession of white instead of yellow gills and stems.



Fly amanita (*Amanita muscaria*): *a*, mature plant; *b*, top view of cap, showing corky patches—both one-half natural size.

fers also in usually having a warty instead of a smooth cap. grow in pine and oak forests from spring to autumn, but the species does not appear so late in the autumn as the other. the common mushroom (*Agaricus campestris*) the fly amanita ly distinguished by having white instead of purple gills and , by its warty cap and bulbous stem, and by its place of growth, eadow mushroom never appearing in forests. The fly amanita ndant in several localities in the United States.

**Poisonous character.**—It is the best known of all the poisonous species. As a fly poison it has been used in Europe for hundreds of years, and the origin of its use in northeastern Asia as an intoxicant is probably not much more modern. Poisoning is, however, not so frequently caused by it as by the closely related and more poisonous death cup (*Amanita phalloides*), yet many cases have been recorded. Cattle are poisoned as well as men, and it is supposed that their flesh is thus rendered unwholesome.

**Symptoms of poisoning.**—The symptoms come on generally within two hours after the fungus is eaten, and consist in a less rapid beating of the heart and an extreme difficulty in breathing. After two or three hours there is a profound stupor, often preceded or accompanied by cold sweats and nervous phenomena—such as giddiness, double vision, and lockjaw. Vomiting sometimes gives relief to the patient, but it is often difficult to produce this effect after stupor has set in, even with the most powerful emetics. This condition may last from eight to ten hours in milder cases, and one or two days in more serious cases. Death follows in from eighteen hours to two or three days, from a gradual weakening and a final stoppage of the heart's action.

There is very little danger of finding either the fly amanita or the death cup (a description of which follows) mixed with the meadow mushrooms sold by regular dealers or brought into market by people who make it a business to do so, but diligence should be maintained by market inspectors in scrutinizing all new kinds of fungi brought in for general sale.

## DEATH CUP.

*Amanita phalloides* (L.) Fr.

**Other names:** Poison amanita; bulbous amanita. (Fig. 2.)

**Description and where found.**—This is not so large or brightly colored as the fly amanita, but is nevertheless decidedly attractive to the inexperienced and experimenting epicure. When fresh it has neither a disagreeable odor nor taste, nor has it any ill appearance due to the presence of larvæ. It grows from 3 to 6 or 8 inches high, and has a smooth, satiny cap, which is strongly convex at first, finally becoming flat or slightly concave. It is usually white or straw-colored, but may be green, light brown, yellow, or even spotted when found growing in dense shade. The stem is white and nearly smooth. The covering present in the fungus when young almost invariably slips away from the cap in this species at maturity and forms a more or less conspicuous cup at the base of the stem, as shown in figure In dry weather it sometimes partially adheres to the cap. The cu is, however, invariably present. In connection with the white gi and spores and the bulbous base, it is the distinguishing feature the species. In general shape the death cup is somewhat like the common mushroom, but it is very much more like another species, the smooth lepiota (*Lepiota naucina*), which is considerably sought after by expert epicures. The lepiota, like the death cup, has a smooth, satiny cap, white gills, and white spores, but it is distinguished by the absence of a sheathing cup and by the ball-and-socket attachment of the stem to the cap, as well as by its occurrence chiefly in meadows. From the common mushroom the death cup may be at once distinguished by its cup, by its white gills and spores, and by its growing in woods instead of in meadows. The death cup is the most poisonous of all the fleshy fungi. It is found usually in pine forests, where it often grows in greater abundance than any other species of fungus. Sometimes, however, it encroaches upon lawns near the borders of woods. The plant is recorded as growing in California and in various parts of the Eastern and Middle States. In the vicinity of Washington, D. C., it is exceedingly abundant in late autumn.

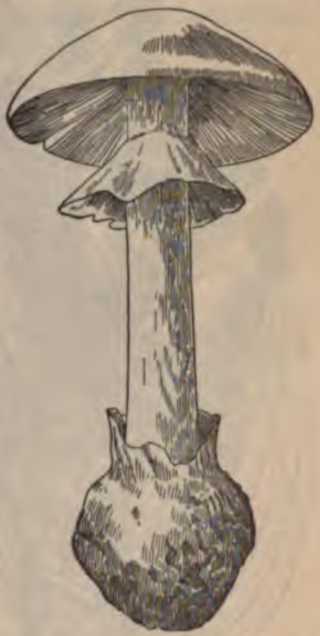


FIG. 2.—Death cup (*Amanita phalloides*), one-half natural size.

**Poisonous character.**—A large number of cases of poisoning have been attributed to this fungus in ancient as well as in modern times. In most of them the plant was taken to be an edible fungus. In a few instances the mere handling of the plant caused serious trouble. A third part of an uncooked medium-sized cap proved fatal to a boy 12 years of age.

The symptoms are characteristic; no bad taste warns the victim, and usually the first effects do not appear until from nine to fourteen hours after eating. There is then considerable pain, and there may be cramps in the legs and other nervous phenomena, such as convulsions and even lockjaw. In a few cases there are spasms. The pulse is weak and either quick or slow in its action. The pupils of the eyes are sometimes dilated. The abdominal pain is rapidly followed by nausea, vomiting, and extreme diarrhea, the discharges assuming the peculiar "rice water" condition characteristic of cholera. The latter symptoms are persistently maintained, generally without loss of consciousness, until death ensues, as it does in from two to four days.

The vernal amanita or destroying angel (*A*[illegible] regarded by some experts as identical with the de[illegible] ne poisonous action.

## AMERICAN FALSE HELLEBORE.

*Veratrum viride* Ait.

**Other names:** American white hellebore; white hellebore; false hellebore; swamp hellebore; Indian poke; meadow poke; poke root (in N. H.); Indian uncus; puppet root; earth gall; crow poison; devil's bite; duckretter; itch weed; bugbane; wolfsbane; bear corn. (Fig. 3.)

**Description and where found.**—A stout, herbaceous, simple-stemmed perennial, 2 to 7 feet high, with a fleshy root 1 to 3 inches long, large, plaited stemless leaves of varying size, and a large, loose, terminal cluster of yellowish-green flowers which blossom from May to July. The plant is native to the United States, where it grows abundantly in wet meadows and along mountain brooks throughout New England; southward in cold localities through New York and Delaware to Virginia, and in the Allegheny Mountains to Georgia; westward in northern Wisconsin, the mountains of Oregon, Washington, and Idaho, and in Alaska.

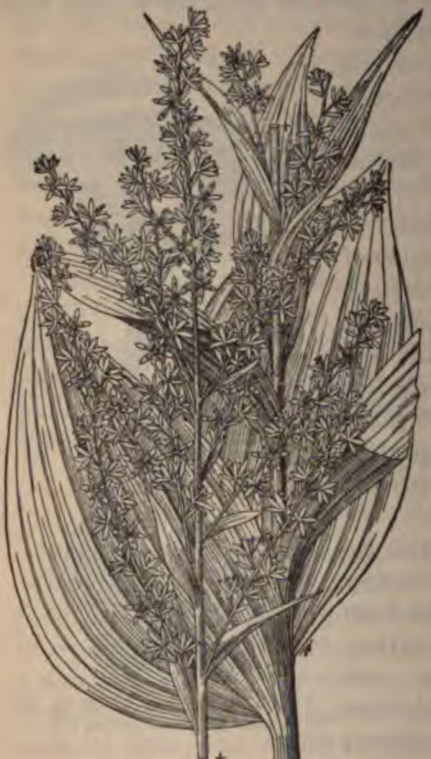


FIG. 3.—False hellebore (*Veratrum viride*), one-third natural size.

**Poisonous character.**—Cases arise mainly from overdoses in medicine, but instances of accidental poisoning are reported for man and for various animals and birds. The seeds have been specially mentioned as poisonous to chickens. Some animals, such as the horse, are poisoned by eating the leaves, but animals such as the sheep and elk, which chew the cud, seem to relish the plant, and eat it with apparent impunity. The root has been eaten with fatal results by human individuals. One instance is recorded where all the members of a household were poisoned by eating the young leaves, which were mistaken for those of marsh marigold (*Caltha palustris*) and prepared for food.

The poison operates chiefly against the action of the heart and spinal cord, both of which it tends to paralyze. It has also a violent, although somewhat tardy, emetic and cathartic effect, a property which is often effective in expelling the poison from the system before it accomplishes its deadly work.

**Symptoms.**—The chief effects on the system are burning in the throat, an increased flow of saliva, defective vision, vomiting, diarrhea, severe headache, dizziness, weak pulse, labored breathing, and profound prostration. Death is caused by paralysis of the heart.

## POKEWEED.

*Phytolacca decandra* L.

**Other names**: Poke; poke root; garget; pigeon berry; cocum; jalap; skoke; American nightshade; crowberry; cancer root; chongras (La.); redweed; red-ink plant; pocan bush. (Fig. 4.)

**Description and where found.**—A smooth, rank, succulent perennial, 6 to 9 feet high, with a thick half-woody root, purplish stems, large alternate leaves, and numerous elongated clusters of small greenish-white flowers, which blossom throughout the summer, and are followed in autumn by shining purple-black berries. The plant is native to the United States, and grows in rich, moist soils, especially as a weed in cultivated and waste grounds, from Maine and northern Illinois to Florida, and westward to Texas, eastern Kansas, and southern Minnesota.

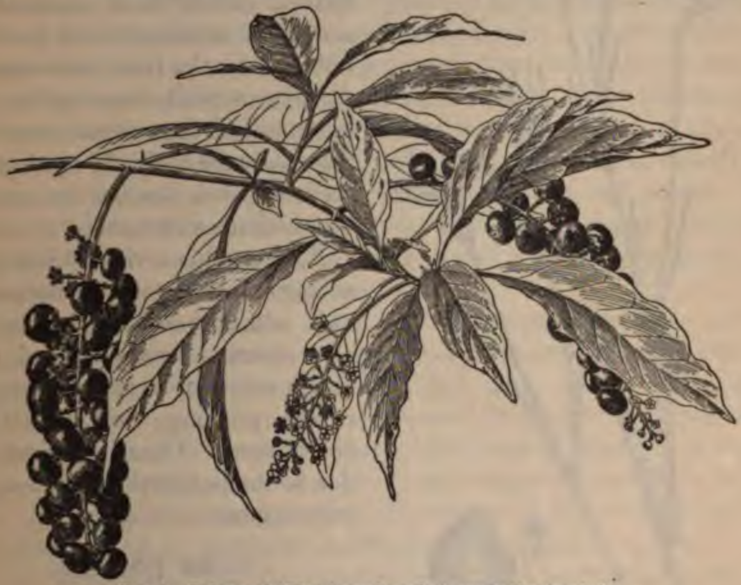


FIG. 4.—Pokeweed (*Phytolacca decandra*), one-half natural size.

**Uses.**—The pokeweed is a well-known plant and has many household uses, but some chemical or mechanical manipulation seems necessary to prevent ill effects when it is eaten. The root and [illegible] holic extract of the fruit are quite commonly used [illegible] remedy for the itch and other skin diseases and for rheumatism fresh shoots are rather widely esteemed as a substitute for asp but in the preparation considerable care is exercised to reject t for small quantities impart a bitter taste to the mess, and amounts will prove dangerous. The water in which the shoots boiled is also rejected on account of the poisonous substance con in it. The flesh of the berries is eaten with impunity by some but its use by human beings can not be recommended.

**Poisonous character.**—Most instances of poisoning arise from doses when the plant has been used as a medicine, but there a accidental cases due to the of the root, which has been ously mistaken for that parsnip, artichoke, and radish. A few fatal cases soning of children have be tributed to the fruit, but w death was really due to th or the pulp is somewhat unc The evidence is chiefly agai seed, for it is known to a poisonous substance.

Pokeweed is a violent b acting emetic, vomiting be only after about two ho also affects the nerves a cles, producing retching, severe purging, and so convulsions. Death is ap due to the paralysis of the tory organs.

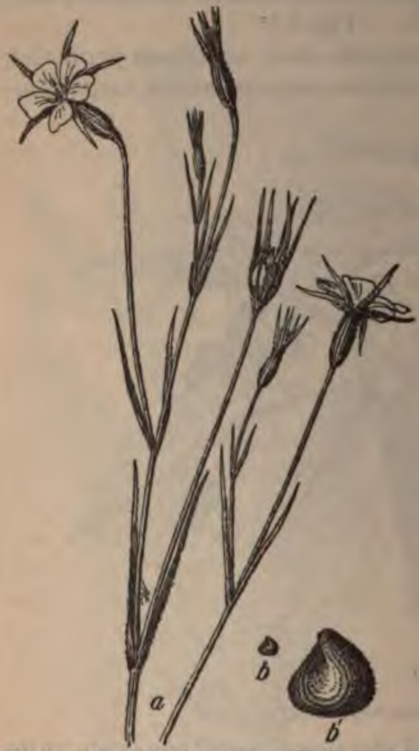


FIG. 5.—Corn cockle (*Agrostemma githago*): *a*, sprays showing flowers and seed capsule, one-third natural size; *b*, seed, natural size; *b'*, seed, four times natural size.

## CORN COCKLE.

*Agrostemma githago* L

**Other names:** Cockle; r pion; bastard nigelle; old pink (N. H.); mullein pin Scotia); licheta (Vt.); crown of the field. (Fig. 5.)

**Description and where found.**—A whitish, woolly annual, 1 high, with an erect stem, showy, violet-red flowers, and n rough, black, irregularly rounded seeds.

The corn cockle is a noxious weed in Europe, and in the States it is now generally introduced in grain fields from M North Dakota, southward through eastern Kansas to Louisi Florida; sparingly in Wyoming and California, and scarcely the dry regions extending eastward from California to Texas and eastern Kansas.

**Poisonous character.**—The poisonous constituent is very freely soluble in water, and possesses a sharp, burning taste. It has no odor, but when inhaled in the smallest quantity it produces violent sneezing. When briskly shaken with water it froths like soap. The poison is found in nearly all parts of the plant, but mainly in the kernel of the seed.

**Ways of poisoning.**—Cases of poisoning have been noted among all sorts of poultry and household animals, but are rarely due to any portion of the plant as found growing in the field. The poisoning is generally produced by a poor grade of flour made from wheat containing cockle seeds. Machinery is used to remove these seeds from the wheat, but the difficulty of separating them is so great that the result is not entirely accomplished. The quantity remaining determines the grade of the flour in this particular regard. In European countries it sometimes amounts to 30 or 40 per cent, but this quality is sent out only by ignorant or unscrupulous dealers, or is intended for consumption by animals only. Flour containing a smaller amount has often been made into bread and eaten, sometimes with fatal results, the baking not always being sufficient to decompose the poison. The effect may be acute, or, if a small quantity of the meal is eaten regularly, it may be chronic. In the latter case it is sometimes known as a disease under the name of "githagism."

**Symptoms.**—The general symptoms of acute poisoning are the following: Intense irritation of the whole digestive tract, vomiting, headache, nausea, vertigo, diarrhea, hot skin, sharp pains in the spine, difficult locomotion, and depressed breathing. Stupor sometimes sets in, and it may be followed by death. Chronic poisoning has not been closely studied in man, but experiments upon animals show chronic diarrhea and gradual depression, the animal losing vigor in breathing and in muscular movements until death ensues.

Corn-cockle meal is easily detected in second and third class flour by the presence of the black, roughened scales of the seed coat. These are sure to occur if the flour has not been well bolted. Its presence is otherwise detected by the peculiar odor produced when the meal is moistened, and by chemical tests with iodine.

Wheat containing corn-cockle seeds should be rejected for planting.

## DWARF LARKSPUR.

*Delphinium tricorne* Michx.

**Other name:** Stagger-weed (Ohio). (Fig. 6.)

**Description.**—The genus Delphinium, formed by the larkspurs, is composed of erect herbs, with palmately lobed leaves, and an elongated cluster of showy flowers. These are commonly b further characterized by the absence of green parts, and the presence of a peculiar spur-like appendage.

There are over 25 species native to the United States. Few have a very wide distribution, but some of the Western species are extremely abundant in their natural place of growth. They have a general reputation of being poisonous to cattle.

The dwarf larkspur is a smooth, simple-stemmed perennial, 6 to 12 inches high, with a tuberous root, deeply 5-parted leaves, and a long, loose cluster of blue (sometimes white) flowers, which appear in April and May. It grows in clayey soil and open woods, from Pennsylvania and the mountains of North Carolina to southern Minnesota. It is especially reported from Ohio as fatal to cattle in April, when the fresh leaves appear.

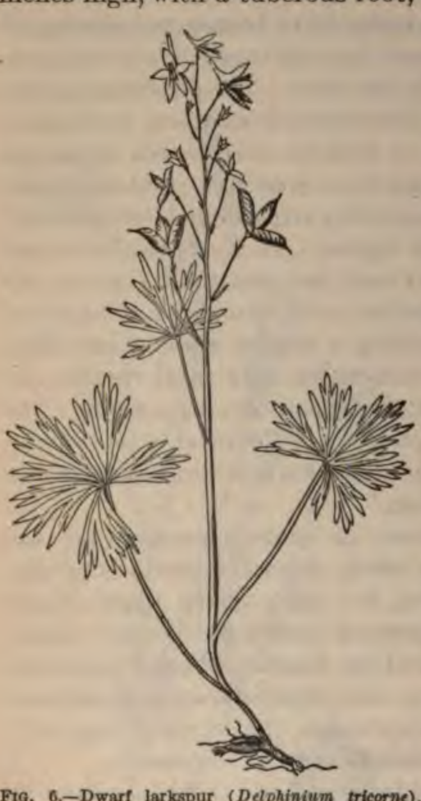


FIG. 6.—Dwarf larkspur (*Delphinium tricorne*), one-third natural size.

### WYOMING LARKSPUR.

*Delphinum geyeri* Greene.

**Other name:** Poison weed.

**Description and where found.**—A somewhat hairy perennial, 10 to 20 inches high, with a large spheroidal tuft of rather thick, dull-green leaves, and a central column of deep azure-blue flowers. A common high prairie plant of Wyoming and northern Colorado. It is reported to be the most troublesome of the poisonous plants of Wyoming. Ranchmen suffer considerable loss from it, especially in early spring, when the dark-green tufts of foliage are conspicuous features of the otherwise dry and barren landscape.

### PURPLE LARKSPUR.

*Delphinium menziesii* DC.

**Description and where found.**—A somewhat hairy, tuberous-rooted perennial, about a foot high, with a basal cluster of finely divided, long-stemmed leaves, and a single column of showy blue flowers, which appear at any time between April and July. The flowers are few in number, but are extra large, being from 1 to 1½ inches broad. This species is found native on hillsides from the vicinity of San Francisco to British Columbia and eastward as far as South Dakota. In Montana it is very common throughout the State.

**Poisonous character.**—The percentage of fatal cases in cattle which have eaten this and other larkspurs is said to be small. A rough estimate by a cattleman places it at about 20 per cent for one species of the group, when the animals are not properly treated, and 5 per cent otherwise. This is probably a low estimate, however, for in a case of poisoning from *D. menziesii* that occurred in Montana in May, 1897, and was reported by Dr. E. V. Wilcox, nearly 600 sheep were affected, 250 of which died.[a]

It is an excellent precaution to allow animals in pastures containing larkspur only when well fed, and then only for short periods, until they become thoroughly familiar with the deleterious nature of the plants.

The tall mountain larkspur (*Delphinium trolliifolium*), sometimes known as cow poison, grows in moist, shady places from Monterey, Cal., to British Columbia. Reports of poisoning come from California and Oregon. The poisonous qualities of this species have, however, been considerably questioned.

A lavender-colored, fleshy-rooted larkspur (*Delphinium recurvatum*) which grows in moist saline soils south of San Francisco and Stockton, in California, is particularly reported as fatal to animals in San Luis Obispo County.

The seed of the European stavesacre (*Delphinium staphisagria*) has long been regarded as a powerful poison. The seed of the commonly introduced larkspur (*D. consolida*) is regarded as less poisonous; the leaf is reputed to be poisonous to cattle in Europe. The leaf of the stavesacre has only recently been shown to be poisonous. The properties of the roots of these and other species are not well known. Little or no attention has yet been paid by American chemists to the native larkspurs; hence it is not known how poisonous they are in comparison with European.

## BLACK CHERRY.

*Prunus serotina* Ehrh.

**Other names:** Wild black cherry; wild cherry; rum cherry; whisky cherry. (Fig. 7.)

**Description and where found.**—A valuable forest tree, 60 to 80 feet high, with thin, reddish-brown, scaly bark, tapering, saw-edged leaves, cylindrical clusters of small white flowers appearing in April and May, and shining-black, edible fruit, about a quarter of an inch in diameter. It grows abundantly in forests in the middle Atlantic and Ohio River States; less commonly in woods and in the open country in the southern New England and Gulf States, and westward from Illinois to South Dakota, eastern Nebraska, and Arkansas. As an ornamental and shade tree it is cultivated extensively in Wyoming and Colorado, and eastward to the Atlantic.

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[a] Since the above was in press, Dr. S. B. Nelson, Professor of Veterinary Sciences in the Washington State Agricultural College, has published (Bull. No. 22, Bureau of Animal Industry, U. S. Department of Agriculture) the results of an experiment made by himself, in which as much as 24¾ pounds of the fresh leaves of this plant was fed to a sheep within a period of five days without any apparent ill effect. An experiment made by Dr. Wilcox (Bull. No. 15, Montana Agricultural Experiment Station) shows that the extract from less than an ounce of the dried leaves killed a yearling lamb in two hours, the dose having been given by way of the

**Fruit.**—The fruit is rather agreeable, being but slightly bitter and astringent in taste. In some localities it is much used to flavor liquor.

**Ways of poisoning.**—Poisoning is frequently caused in cattle by eating the wilted leaves from branches thrown carelessly within their reach or ignorantly offered as food. Children occasionally die from eating the kernels of the seed or from swallowing the fruit whole.

**Symptoms.**—The prominent symptoms of black-cherry poisoning observed in cattle are labored breathing, diminished pulse, numbness, protruding eyeballs, convulsions, and death from paralysis of the lungs. In some cases there is considerable frothing at the mouth; in all there is a very perceptible odor of prussic acid in the breath.

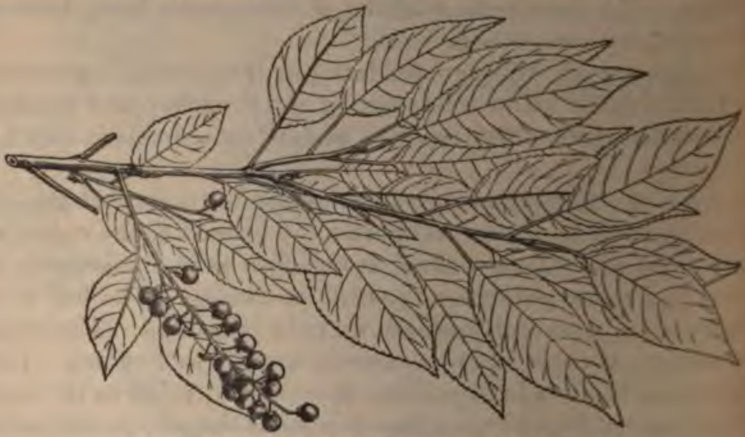

FIG. 7.—Black cherry (*Prunus serotina*), one-third natural size.

The freshly cut branches of the trees should in no case be thrown where cattle can get at them.

## WOOLLY LOCO WEED.

*Astragalus mollissimus* Torr.

**Other names:** Loco weed; crazy weed. (Fig. 8.)

**Description and where found.**—A silvery-white, silky-leaved perennial 8 to 12 inches high, with an abundance of soft foliage springing out in a cluster from a short central stem close to the ground. The flowers are pea-shaped and usually purple. The pod is distinctly two-celled. This plant is native to the Great Plains region, extend ing from western Texas and New Mexico northward to South Dakota and Wyoming, being most abundant in Colorado and in the western part of Nebraska and Kansas. It grows both on the open prairie and on rocky hillsides.

**How stock are affected.**—Horses, cattle, and sheep are affected by loco, but the principal damage is done to horses. The effect is not acute, but in its slow progress simulates diseases caused by bacteria, worms, or other parasites or such as are caused in man by the continued use of alcohol, tobacco, or morphine. Two stages are recognized. The first, which may last several months, is a period of hallucination or mania accompanied by defective eyesight, during which the animal may perform all sorts of antics. After acquiring a taste for the plant it refuses every other kind of food, and the second stage is ushered in. This is a lingering period of emaciation, characterized by sunken eyeballs, lusterless hair, and feeble movements. The animal dies as if from starvation, in periods ranging from a few months to one or two years.

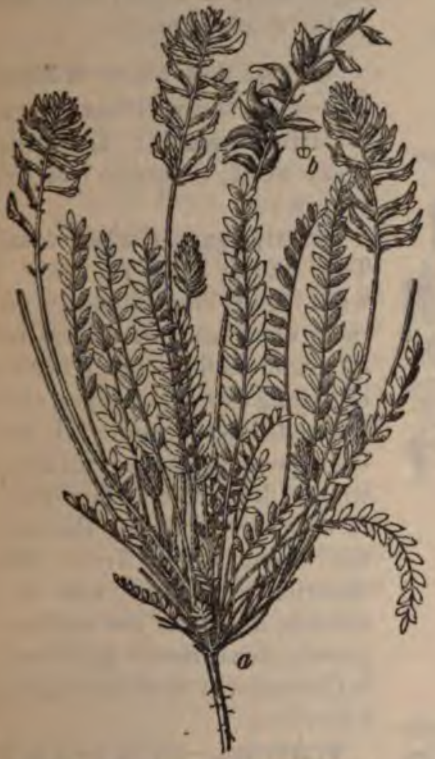

FIG. 8.—Woolly loco weed (*Astragalus mollissimus*): *a*, whole plant; *b*, cross section of pod—both one-third natural size.

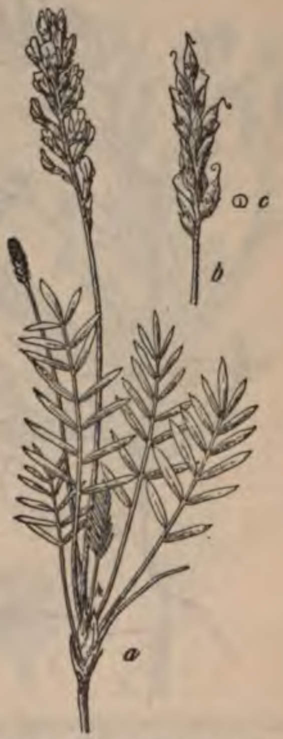

FIG. 9.—Stemless loco weed (*Aragallus lambertii*): *a*, flowering plant; *b*, seed pods; *c*, cross section of seed pod—all one-third natural size.

**Damage done.**—The damage done to the live-stock business by this weed is immense. As mentioned in the introduction, the State of Colorado paid out nearly $200,000 in bounties between 1881 and 1885 in an attempt to exterminate it.

This genus contains a large number of species, and it is quite probable that many of these should be considered to be poisonous where they grow over wide areas of pasture land, and are green at periods when there is but little green grass. Over a half dozen have been reported to the Department of Agriculture as highly detrimental to the stock industry.

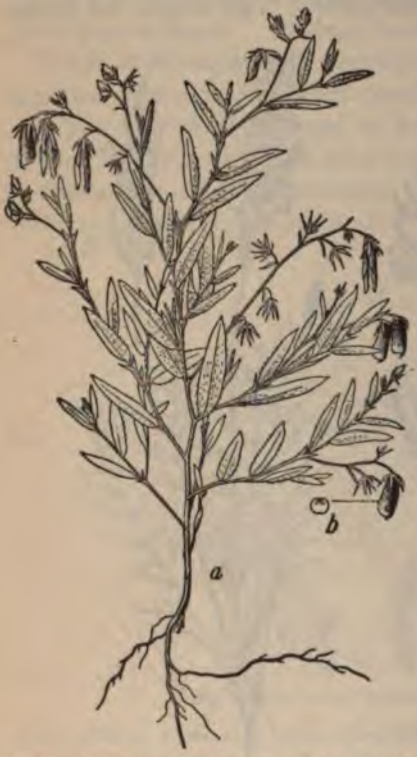

FIG. 10.—Rattlebox (*Crotalaria sagittalis*): *a*, whole plant; *b*, cross section of seed pod—both one-third natural size.

## STEMLESS LOCO WEED.

*Aragallus lambertii* (Pursh) Greene.

**Other names:** Loco weed; crazy weed; Colorado loco vetch. (Fig. 9.)

**Description and where found.**—This differs from the true loco weed most conspicuously in its more erect and branchless habit, its longer leaflets, which are linear or oblong instead of ovate, and the one-celled seed pod. It ranges over the same territory as does the woolly loco weed, but extends farther, being found throughout the Great Plains from British America to Mexico, and it also ascends higher in the mountains, growing luxuriantly at Silver Cliff, in Colorado, at an altitude of about 8,000 feet.

**Symptoms.**—So far as has been observed, the symptoms of poisoning are identical with those produced by the preceding species. The two plants are considered to be equally prejudicial to the stock-raising interests of New Mexico.

## RATTLEBOX.

*Crotalaria sagittalis* L.

**Other names:** Rattleweed; wild pea. (Fig. 10.)

**Description and where found.**—A hairy annual, 3 to 18 inches high, with simple undivided leaves, 1 to 2 inches long, and small, yellow, *pea-like* flowers appearing in July. The seed pods are about an inch *in length* when mature, and are nearly black. They are much inflated, and as the walls are stiff and thin and very resonant, they make excellent minature rattles when the seeds have become detached from their fastenings inside the pod. The rattlebox is native in low, sandy soils from the Atlantic westward to Minnesota and eastern Kansas; also in New Mexico. It is common in Connecticut, New Jersey, and North Carolina, and in some years is very abundant in bottom lands along the valley of the Missouri, in South Dakota, and Iowa.

**Poisonous character.**—The poisonous constituent is unknown, but it resides both in the leaves and in the seeds. Horses, and sometimes cattle, are killed by eating grass or meadow hay mixed with the plant. They are not poisoned so often by eating the plant in the field. Public attention was first called to the poisonous nature of rattlebox by Dr. Stalker, of Iowa, who in 1884, while investigating the cause of "bottom disease," then prevalent among horses in Iowa, was led to believe that it was mostly if not altogether attributable to this plant. Experiments were made which proved the supposition to be correct.

**Symptoms.**—As generally decribed from accidental cases, the symptoms are much prolonged, death resulting only after several weeks or months. There is a general decline of vigor and a gradual loss of flesh, as observed in the case of loco, with which this plant is closely related. The rattlebox does not, however, appear so often to produce the craziness characteristic of loco.

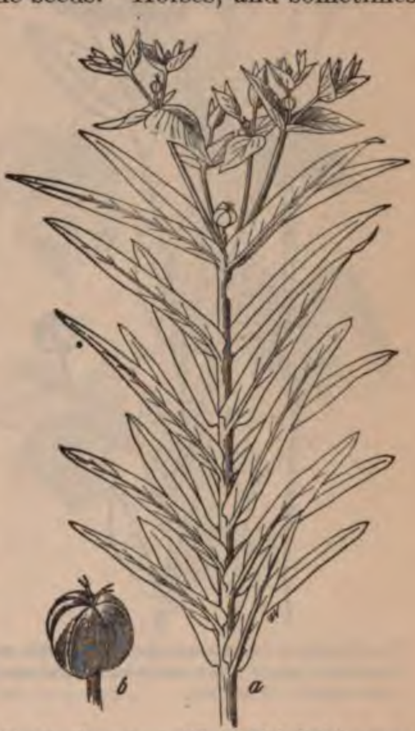

FIG. 11.—Caper spurge (*Euphorbia lathyris*): *a*, upper half of plant, one-third natural size; *b*, seed capsule, natural size.

The percentage of rattlebox in meadow hay will be much reduced if the fields are burned over when the seeds mature the preceding summer. The growth of perennial grasses will not be materially affected thereby.

## CAPER SPURGE.

*Euphorbia lathyris* L.

**Other names:** Garden spurge; myrtle spurge; mole plant; mole weed; mole tree; gopher plant; antigopher plant; wild caper; caper bush; wolf's milk; springwort. (Fig. 11.)

**Description and where found.**—A smooth herbaceous, milky-juiced perennial, 2 to 3 feet high, with a stiff, erect stem, and opposite, four-ranked leaves, the lower of which are thick and oblong, the upper thin, broad, and heart-shaped. The flowers are greenish-yellow and rather small. The three-seeded fruit is conspicuous. It is a common garden plant, sparingly introduced in wet ground in California and Texas, and in the Atlantic States from New Jersey to West Virginia and North Carolina.

**Poisonous properties.**—The fresh milky juice is exceedingly acrid and the fruit is highly purgative and poisonous. When used as a household remedy it often provokes serious trouble. Women and children are not infrequently poisoned by handling the plant and getting the juice on the face. Cattle are quite resistant to its influence, but they are sometimes overcome. Goats will eat the plant extensively if nothing better presents itself, and it is said that their milk then possesses all of the venomous properties of the plant. When applied to the skin the juice causes redness, itching pimples, and sometimes gangrene, the effect often lasting more than a week. The seed taken internally in overdose will inflame the mouth and stomach, and cause intense diarrhea and vomiting. If the dose is sufficient, there will be nervous disorders, unconsciousness, general collapse, and death.

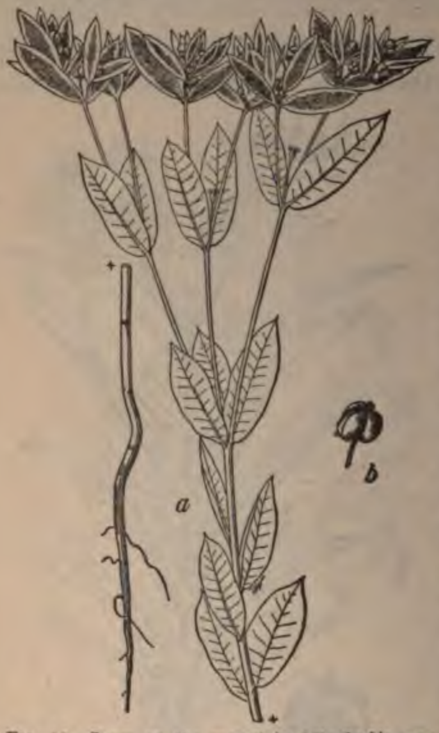

FIG. 12.—Snow on the mountain (*Euphorbia marginata*): *a*, whole plant, one-third natural size; *b*, seed capsule, natural size.

## SNOW ON THE MOUNTAIN.

*Euphorbia marginata* Pursh.

**Description and where found.**—An annual plant 2 to 4 feet high differing most conspicously from the preceding species in its more slender and less branching habit, and in having its upper leaves broadly margined with white. (Fig. 12.) Its general aspect is far more pleasing to the eye, and on this account it is more frequently gathered for decorative purposes. This spurge is a native weed of the Grea ins from Montana to Mexico, and is spreading eastward rapidly to iisiana and through southern Minnesota and Missouri to Wiscon- Illinois, and Indiana. It is cultivated considerably for ornament, ecially in the Northern Atlantic States, where it has frequently iped from cultivation. It recently been introduced as eed into Germany.

**oisonous property.**—The poi- of this plant reaches the nach so far as known only ugh the eating of honey de- d from its flowers. Large ntities of fall honey are an- ly made unsalable in locali- where the plant grows in t abundance. The honey ot and disagreeable to the , but does not appear to be ry serious poison, its effects g confined mostly to vom- and purging. The milky , when it gets on the skin, often causes an itching in- nation, accompanied by ples and blisters which last several days. The general t is much like that observed hus poisoning, for which it ometimes mistaken. This tering action is, in fact, so ided that a few stock raisers exas use the juice to brand tle, it being held by them to be superior to a red-hot iron for that pose, because the scar heals more satisfactorily.

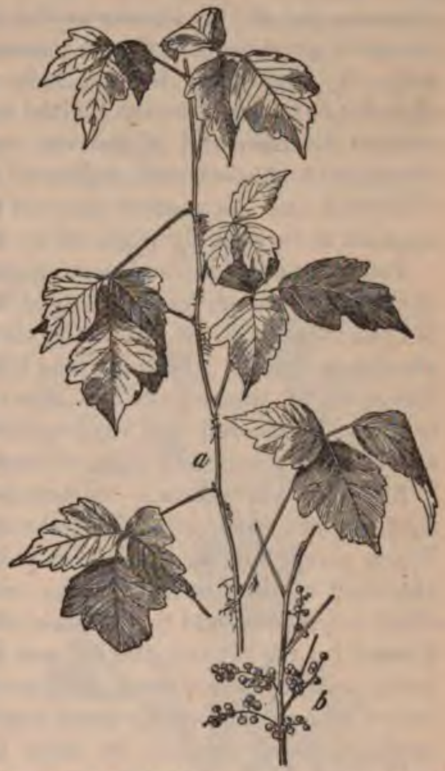

FIG. 13.—Poison ivy (*Rhus radicans*): *a*, spray showing aerial rootlets and leaves; *b*, fruit—both one-fourth natural size.

## POISON IVY.

*Rhus radicans* L.

**ther names:** Poison oak; poison vine; three-leaved ivy; poison eper; mercury or markry (N. H. and N. J.); black mercury (Me.); rkweed (Me.); pickry (Me.). (Fig. 13.)

**escription and where found.**—A climbing or trailing shrub (some- es erect), with variable three-foliate leaves, aerial rootlets, and enish flowers, appearing in May and June. The smooth, waxy, te fruit often remains on the plant until late in winter. The leaves n resemble those of the box elder, as in the figure. They differ

from those of the Virginia creeper in havin
of five. Poison ivy grows everywhere in
on the borders of woods, and it is spread
vated fields from seeds carried by crows
birds that feed upon its fruit in winter. T
lessness, and at the imminent risk of causi
to many persons, this vine is sometimes pl
even city residences for the sake of orn
abundance throughout the United States a
eastern Kansas, and Minnesota, and in g
throughout the less arid region of the We
California and the western parts of Oregon
appears to be entirely replaced by *Rhus di*

**Poisonous character.**—Recent experiment
of the Harvard University Medical School, h
is a nonvolatile oil. It is found in all parts of
after long drying. Like all oils, it is insolu
therefore be washed off the skin with w
removed by alcohol, and very easily destroy
an alcoholic solution of sugar of lead (lead

**Effect of the poison.**—Numerous exper
that the oil produces precisely the same eff
When a very minute amount is placed upo
absorbed in the course of a day or so, and
effect is proportional to the time of contac
formed by the writer, the oil was applied
wrist, and these were carefully guarded to p
end of an hour one of the spots was thorou
applications of alcohol; in three hours th
washed off in the same manner, and the o
hours later. There was little or no effect
second was more marked, but did not equal
two, which was about the same in each.
inch of each other, but remained wholly d
clearly shows that the affection is not spre
quent applications of an alcoholic solution of
and permanent relief.

**Remedies.**—In practice it is not desirab
which is apt to be too irritating to a sensit
grade of from 50 to 75 per cent is recomme
dered sugar of lead is to be added until no
The milky fluid should then be well rubbed
the operation repeated several times during
The itching is at once relieved and the furth
is checked. The remedy has been tried in a

has always proved successful. It must be remembered, however, that the lead solution is itself very poisonous if taken internally.

**Restrictive and preventive measures.**—It is highly desirable that legal measures be adopted compelling the destruction of these plants where they abound in cities and in places of popular resort. This can be managed without much danger from the poison, and is a matter of very general public interest. As has already been noted, many individuals are practically immune from the effects of poison ivy. Advantage should be taken of this fact to employ such individuals to remove these plants from the vicinity of dwellings and from playgrounds. Much of the work would be purely mechanical, consisting in rooting the plants up by main force. This is the most certain method; the use of concentrated sulphuric acid is attended with less danger, as the plants do not need to be touched. A half teaspoonful should be applied to the stem every two or three weeks in the springtime when the plant is growing most vigorously. Care should be taken to keep the acid away from the skin, as it is most highly corrosive. The brush should in no case be left upon the ground nor the wood used for fuel. In burning the refuse in the field, pains should be taken not to inhale the smoke nor to handle the wood any more than necessary.

The greatest care should be exercised in preventing workmen from transferring the oil from their clothes and hands to other individuals. To accomplish this object special suits should be worn, and the hands should be washed several times a day with the alcoholic sugar of lead solution described above. Bathing in hot water with strong soapsuds is recommended. The clothing must also be well washed, and it is always well to remember that towels may be a means of conveying the oil.

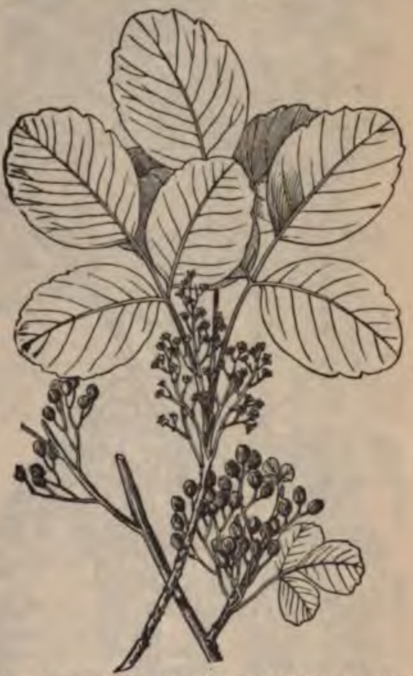

FIG. 14.—Poison oak (*Rhus diversiloba*), showing leaves, flowers, and fruit, one-third natural size.

## POISON OAK.

*Rhus diversiloba* Torr. & Gr.

**Other names:** Poison ivy; yeara; California poison sumac. (Fig. 14.)

**Description and where found.**—The poison oak differs from the preceding species mainly in the character of its leaflets somewhat thicker and smaller, more nearly elliptical, and less sharply lobed. Their similarity to the leaves of the Western oaks gives the plant its common name. The poison oak grows at low elevations in open woods, on bushy hillsides and ravines, and sometimes along fences, in Arizona and to the west of the Sierra Nevada and Cascade ranges in California, Oregon, and Washington. It does not, however, frequent the higher mountains.

**Poisonous character and remedy.**—This species produces about the same effect on the human skin as the poison ivy, and cases of poisoning are to be treated in the same way.

### POISON SUMAC.

*Rhus vernix* L.

**Other names:** Swamp sumac; dogwood (Mass.); poison dogwood; poison elder (Ala.); poison ash (Vt.); poison tree; poison wood; poison swamp sumac; thunderwood (Ga., Va.). (Fig. 15.)

**Description and where found.**—A tree-like shrub 6 to 30 feet high, with long pinnate leaves having from 7 to 13 leaflets, without marginal teeth. The wood has a faint sulphurous odor, which, together with the leaf scars, which are very prominent, enables one to distinguish the plant from other shrubbery in winter. It grows in swamps and in damp woods from Florida to Canada and westward to Louisiana.

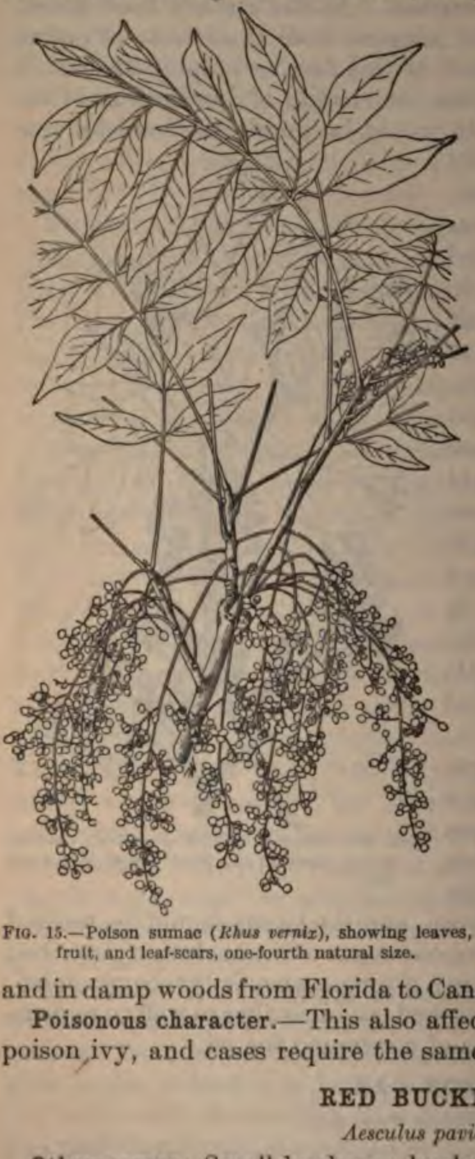

FIG. 15.—Poison sumac (*Rhus vernix*), showing leaves, fruit, and leaf-scars, one-fourth natural size.

**Poisonous character.**—This also affects the skin in the same way as poison ivy, and cases require the same remedy.

### RED BUCKEYE.

*Aesculus pavia* L.

**Other names:** Small buckeye; buckeye; horse-chestnut.

**Description and where found.**—A shrub 8 to 12 feet high, with opposite long-stemmed leaves, and numerous clusters of bright red flowers.

which appear in March. The fruit is smooth, even when young; the seeds are mahogany-colored and are elegantly polished. The red buckeye is native in fertile valleys from Virginia to Florida, throughout the Gulf States to Louisiana, and in Arkansas. It is sparingly represented in Missouri, Tennessee, Kentucky, and West Virginia. It is cultivated to some extent in Pennsylvania.

**Poisonous character.**—The records of its poisonous action are mostly confined to its use as a means of procuring fish, but cattle are sometimes killed by eating the fruit. It was formerly, and perhaps is still, the practice to stir the bruised seeds or twigs into small ponds and gather the stupefied fish by hand as they rise to the surface. When thoroughly cooked these fish are quite wholesome.

**Other species.**—The common horse-chestnut (*Aesculus hippocastanum*) is poisonous. In England, however, it is fed to cattle after the removal of the poison by thorough washing with alkali. Cases of poisoning by this and the next species have arisen from overdoses in medicine. The Ohio buckeye (*Aesculus glabra*) is regarded as intermediate between the above species in its poisonous qualities. The fruit of the California buckeye (*Aesculus californica*) is sometimes made into soup and bread by the Round Valley Indians, after removing the poison by roasting and leaching.

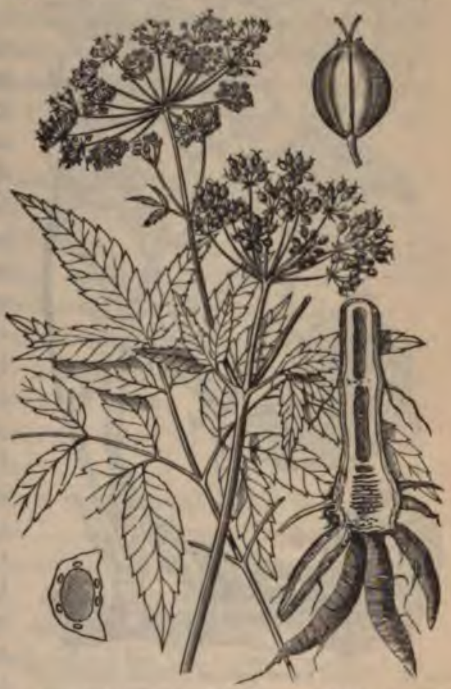

FIG. 16.—Water hemlock (*Cicuta maculata*), showing section of spindle-shaped root and lower stem, the leaves, flowers, and fruit one-half natural size; also fruit and cross section of seed, enlarged five times.

## WATER HEMLOCK.

*Cicuta maculata* L.

**Other names:** American water hemlock; wild hemlock; spotted hemlock; spotted parsley; snakeweed; beaver poison; musquash root; muskrat weed; cowbane; spotted cowbane; children's bane; death of man. (Fig. 16.)

**Description and where found.**—A smooth, erect [illegible] 8 feet high, with a rigid, hollow stem, numerous [illegible] sected leaves, white flowers, and a cluster of spindle-shaped roots, which vary in length from 1½ to 3 inches, and are very characteristic of the plant. It grows commonly in swamps and damp soil, throughout the Atlantic States, westward to Louisiana, Iowa, and Minnesota; much less commonly northwestward through Nebraska to the Rocky Mountains, and in New Mexico.

**Poisonous property.**—This is one of the most poisonous native plants in the United States, being rapidly fatal to both man and animals. The roots are especially dangerous, because the taste, being aromatic and to some people suggesting that of horse-radish, parsnips, artichokes, or sweet cicely, is apt to lead children to eat them when they are found forced out of the soil by washing, freezing, or other causes in early spring. Cattle sometimes eat the tubers, and in marshes they are poisoned by drinking water contaminated by the juice of roots which have been crushed by being trampled upon. No estimate can be made of the amount of damage done to live stock, but it is very considerable. The human victims average several per annum. In the State of New Jersey alone, as mentioned in the introduction, two quadruple cases were reported during the spring of 1896, which resulted in the death of two individuals.

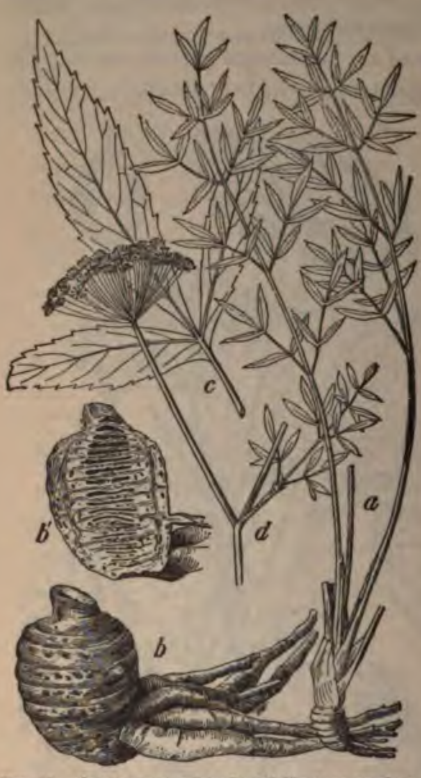

FIG. 17.—Oregon water hemlock (*Cicuta vagans*): *a*, plant with leaves, one-sixth natural size; *b*, rootstock and horizontal roots; *b′*, section of rootstock, half size; *c*, terminal leaflets, one-sixth natural size; *d*, flowering spray, full size.

**Symptoms.**—The prominent symptoms are vomiting, colicky pains, staggering, unconsciousness, and frightful convulsions, ending in death.

### OREGON WATER HEMLOCK.

*Cicuta vagans* Greene.

**Other names:** Water hemlock; cicuta. (Fig. 17.)

**Description and where found.**—A smooth perennial, with erect or straggling glaucous stems 3 to 6 feet high, compound leaves, which spring directly from the ground, white flowers, blooming in July and gust, and a fleshy root, which has a muskrat-like odor, and which sists of two very distinct and characteristic parts. The more spicuous of these is the vertical rootstock, which is from 1 to 6 hes long by 1 or 2 thick, and is curiously divided into numerous mbers by horizontal partitions. This rootstock furnishes the k of the poison. The other portion of the root consists of solid, ny fibers, which run along on or just under the surface of the soil, send off numerous rootlets from beneath. The rootstock rots or ndles away almost entirely before the seeds mature, but fresh s are formed from it for the next season's growth. The plant ws in wet or marshy places, and ranges from British Columbia and o southward to northeastern California, and perhaps to the hern Sierra Nevada.

**ases of poisoning.**—Cases of cattle poisoning have been reported n Victoria, British Columbia; Colby, Wash.; from various parts Oregon, and from northern California. Prof. U. P. Hedrick, of vallis, Oreg., who has investigated cases of poisoning from this nt, believes that more than one hundred cattle are killed by it ry year in Oregon. A piece of the winter rootstock the size of a nut was found to be fatal to a cow. A piece the size of a ble is looked upon as dangerous to man. Human cases are numerous, but a few have been reported in which individuals bled at the root through curiosity.

he Oregon water hemlock has often been mistaken for the preced- species, and also for *Cicuta virosa* L., but neither of these occur in far Northwestern States. Some other plants that are mistaken it are the so-called "wild celery" (*Oenanthe sarmentosa*), Oregon et cicely (*Glycosma ambigua*), and poison hemlock (*Conium ulatum*). These are easily distinguished by the root, which in no e resembles the one here figured.

When these plants occupy large areas, the only safeguard for cattle o keep them on other pastures, especially when they are hungry. e plants may be destroyed by hand pulling when they occur in small ntities near dwellings or playgrounds.

## POISON HEMLOCK.

*Conium maculatum* L.

**ther names:** Hemlock; wild hemlock; spotted parsley; stinkweed; b bennet; poison root; poison snakeweed; cashes; wode-whistle. g. 18.)

**escription and where found.**—A smooth, purple-spotted, hollow- nmed biennial, 2 to 7 feet high, with large parsley-like leaves and vy clusters of small white flowers, which appear in July and ust. The seed is prominently ridged, and has on its inner sur- a deep, narrow, longitudinal groove. The fresh leaves have

an extremely nauseating taste, and when bruised emit a c
istic mouse-like odor. Poison hemlock is native to Europe
but has become naturalized in the United States, and i
common on waysides and in waste places in New York, West
Pennsylvania, New Jersey, and Ohio, and not rare in the New
States and in Michigan. It is infrequent in Wisconsin,
Louisiana, and California, but in some localities in the latter
has a very rank growth.

**Character of the poison.**—The characteristic poison of the he
the well-known volatile alkaloid, conin, which is found in th
and, especially at floweri
in the leaves. The root i
harmless in March, Ap
May, but is dangerous
wards, especially during t
year of its growth. The
hemlock is the most ge
known poisonous plant h
ally, it being without
doubt the plant administe
the Greeks to Socrates an
state prisoners. Recent
poisoning have arisen ac
ally from eating the seed f
of anise, the leaves for p
or the roots for parsnip
from blowing whistles mad
the hollow stems. It has
ly been shown that some
anise seed in both forei
domestic markets is co
nated with hemlock see
it is not known whethe
ous consequences have n
therefrom.

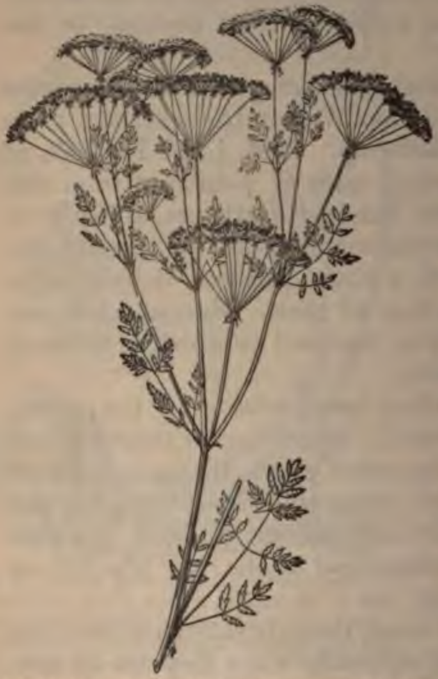

FIG. 18.—Poison hemlock (*Conium maculatum*), showing upper portion of plant, with flowers and seed, one-third natural size.

**Symptoms.**—The symptoms in man are such as are due to a
and gradual weakening of muscular power. The power of
often lost, but the mind usually remains clear until death ens
it soon does from the gradual paralysis of the lungs. The poi
differs from that of the water hemlock (*Cicuta maculata*)
absence of convulsions. Many domestic animals have bee
by eating the plant, the prominent symptoms described fo
being loss of appetite, salivation, bloating, much bodily pa
of muscular power, and rapid, feeble pulse.

As this plant does not often occur in great quantity in the United States, it may usually be destroyed by hand pulling before maturity.

## BROAD-LEAF LAUREL.

*Kalmia latifolia* L.

**Other names:** Laurel (north of Md.); ivy (south of Md.); mountain laurel; sheep laurel; poison laurel; wood laurel; small laurel; rose laurel; high laurel; American laurel; poison ivy; ivy bush; ivy wood; big ivy; calico bush; spoonwood; kalmia; wicky. (Fig. 19.)

**Description and where found.**—A fine shrub, usually 4 to 8, but sometimes 30 to 40 feet high. It has thick, flat, and shining leaves, showy clusters of peculiarly shaped, viscid, and mostly inodrous pink flowers, which appear in May and June, and a globular, viscid, dry, and inedible fruit. It grows abundantly on rocky hillsides, in cattle ranges, and on mountain slopes up to 3,000 or 4,000 feet, from Connecticut to eastern Ohio and along the Alleghenies to Georgia and Alabama; less abundantly in the New England and Southern States as far as Louisiana and Arkansas.

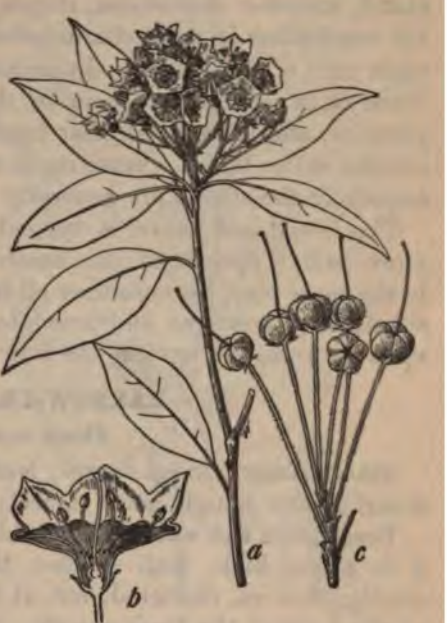

Fig. 19.—Broad-leaf laurel (*Kalmia latifolia*): *a*, flowering spray, one-third natural size; *b*, vertical section of flower showing peculiar attachment of stamens, natural size; *c*, fruiting capsules, natural size.

**Ways of poisoning.**—Scores of cattle and sheep are poisoned annually by eating the shrub. Access to it is generally obtained by breaking away from inclosures, or through neglect or accident when cattle or sheep are being driven past laurel thickets to upland pastures in early spring. Laurel leaves (commonly used for decorative purposes in winter), or the flowering branches, are often carelessly thrown into inclosures where animals are kept. The older cattle are not so frequently killed by it, but they are by no means immune. Horses and even goats have died from eating the leaves.

It is stated that chickens have been poisoned by eating the vomited matter from poisoned animals. Experiments show, however, that they are able to withstand considerable quantities of the pure poison when it is fed to them. In these experiments the chickens were killed with chloroform after dosing for a few days. T were then cast aside, and the well-boiled and well-cleansed meat was fed to cats with nearly fatal results.

The honey derived from the nectar of the flower appears to be poisonous under some conditions. Cases of human poisoning occur indirectly in the ways indicated above; directly by overdoses, or improper use in domestic medicine, probably by the secret and criminal use of the leaves to increase the intoxicating effects of liquors, and, in children, by their eating the young shoots by mistake for the wintergreen (*Gaultheria procumbens*).

**Symptoms.**—The general symptoms in sheep may be taken as representative for those in cows and goats. They are as follows: Persistent nausea, with slight but long-continued vomiting and attempts to vomit, frothing at mouth, grating of teeth, irregular breathing, partial or complete loss of sight and feeling, dizziness, inability to stand, extreme drowsiness, stupor, and death. The irregularity of the respiration is most characteristic, being present throughout the main part of the attack. In addition to most of the above effects there is, in man, severe pain in the head, an increased tendency to perspire, and often a peculiar tingling sensation in the skin throughout the entire body. Vomiting is very copiously produced, and consequently the effects are generally less severe than in animals.

The broad-leaf laurel is typical in its effects of a half dozen or more native species of the heath family. They are all poisonous in the same way, because they all contain the same toxic or poisonous substance, known as andromedotoxin. Many fatalities among animals are recorded against the four species whose descriptions follow:

### NARROW-LEAF LAUREL.

*Kalmia angustifolia* L.

**Other names:** Sheep laurel; lambkill; sheep poison; lamb laurel; dwarf sheep laurel; small laurel; low laurel; dwarf laurel; wicky.

**Description and where found.**—Like the preceding, but smaller, only 2 to 4 feet high, with smaller, thinner, and narrower leaves, and smaller flowers, clustered, not at the extreme end of the stem, but at the base of the fresh shoots. It is abundant at low altitudes in both dry and wet soils from Maine to New Jersey; less abundant westward throughout the Great Lakes region and southward to Tennessee and South Carolina.

### GREAT LAUREL.

*Rhododendron maximum* L.

**Other names:** Laurel (south of Pa.); rosebay; mountain laurel; rhododendron; American rosebay; big laurel (Pa.); big-leaf laurel (Pa.); horse laurel (Pa.); deer tongue; cow plant (Vt.); spoon hutch (N. H.)

**Description and where found.**—A large evergreen bush or small tre 10 to 20 or 30 feet high, with thick leaves, 4 to 10 inches long, at splendid clusters of large, inodorous, pale pink, or nearly white flowers, blossoming in July. A commonly cultivated ornamental tree, native to the Allegheny Mountains, but extending northward in isolated patches to Connecticut and New Hampshire.

### STAGGERBUSH.

*Pieris mariana* (L.) Benth. & Hook.

**Other name:** Kill lamb. (Fig. 20.)

**Description and where found.**--A weak-limbed deciduous shrub, 2 to 4 feet high, with thick, conspicuously veined leaves and showy clusters of tubular white flowers. It is frequent in low, damp soils near the coast from Connecticut to Florida.

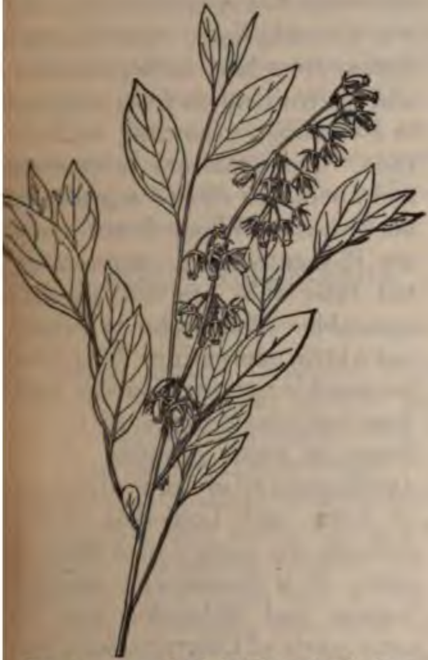

FIG. 20.—Staggerbush (*Pieris mariana*), showing flowering branch, one-third natural size.

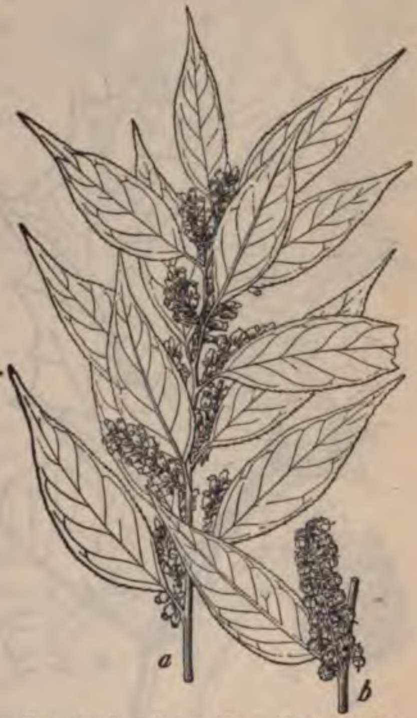

FIG. 21.—Branch ivy (*Leucothöe catesbaei*): *a*, flowering branch; *b*, fruiting capsules—both one-third natural size.

### BRANCH IVY.

*Leucothöe catesbaei* (Walt.) A. Gray.

**Other names:** Hemlock; calf kill; leucothöe; dog laurel. (Fig. 21.)

**Description and where found.**—An evergreen shrub, 2 to 4 feet high, with thick, tapering, sharply saw-edged leaves and numerous clusters of small, white, tubular, ill-smelling flowers, which appear in April or May. It grows abundantly, often forming dense thickets along stream banks in the Allegheny Mountains from West Virginia to Georgia.

## JIMSON WEED.

*Datura stramonium* L.

**Other names:** Jamestown weed; common stramonium; th
apple of Peru; devil's apple; mad apple; stinkwort; stinkweed
Jamestown lily (N. C.); white man's plant (by Indians).

**Description and where found.**—The jimson weeds are rank, il
plants, with large funnel-shaped flowers and prickly four-va
pods. They are mostly weeds which have been introduced
United States from Europe and tropical America. The presen
is a stout, smooth, bush
2 to 5 feet high, with
green stem, large flaccid
and white, heavy-scented
2 to 4 inches long. The
appear from May to Sep
and the fruit ripens from
to November, according
tude. The seeds are n
and about the size of a
buckwheat. When fres
are ill-scented and nau
but later they are not
agreeable. The nectar i
but a little nauseating.
son weed is native to Eu
Asia, but is now common
duced in waste grounds
dwellings in all of the St
of Iowa and Louisian
perhaps, the exception o
sota. It is common in
Kansas and Nebraska,
some parts of Colorado,
probably obtained so
hold in all of the
States.

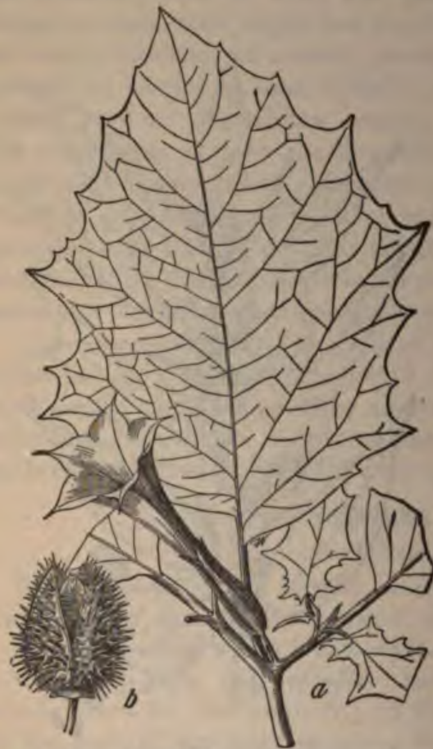

FIG. 22.—Jimson weed (*Datura stramonium*): *a*, flowering spray; *b*, fruiting capsule—both one-third natural size.

The purple-stemmed jimson weed (*Datura tatula*) is a so
taller plant, with purplish flowers and stems, but otherwise pr
identical with the preceding, both in botanical and toxic ch
It is more abundant toward the South and West than the ot

**Ways of poisoning.**—Cases of poisoning arise in adults from e
use as a stimulant or as a medicine. Children are sometimes
to eat the fruit if they are permitted to play where the weed
found. Several cases of this kind were reported to this Dep

ing the fall of 1897. At Alpena, Mich., five children were badly
soned in August by eating the seeds of the purple-flowered species,
ich was cultivated in a garden as a curiosity under the fanciful
le name of "Night-blooming Cactus." Several other cases where
ldren have been poisoned by this plant have been reported. Chil-
n are also poisoned by sucking the flower or playing with it in the
uth. The fresh green leaves and also the root have occasionally
n cooked by mistake for other wild edible plants. One or two
tances are recorded in which cattle have been poisoned by eating
leaves of young plants which were present in grass hay.

**ymptoms.**—The symptoms of the
soning are headache, vertigo,
sea, extreme thirst, dry, burning
, and general nervous confusion,
dilated pupils, loss of sight and
oluntary motion, and sometimes
ia, convulsions, and death.

he jimson weeds should be re-
ed from vacant lots by mowing
plants while in flower or by cul-
ting the soil.

### BLACK NIGHTSHADE.

*Solanum nigrum* L.

**ther names**: Common night-
de; nightshade; deadly night-
de; garden nightshade. (Fig. 23.)

**escription and where found.**—The
k nightshade is a smooth annual,
2 feet high, with rough, angular,
ely branching stems; ovate
es, 2 to 4 inches long, with wavy
gins; drooping clusters of small
te flowers, and black, globose,
y berries, which ripen from July
October. It is a common intro-
ed weed in rich shaded grounds and fields east of South Dakota
Arkansas, and in damp places westward to the Pacific Ocean.

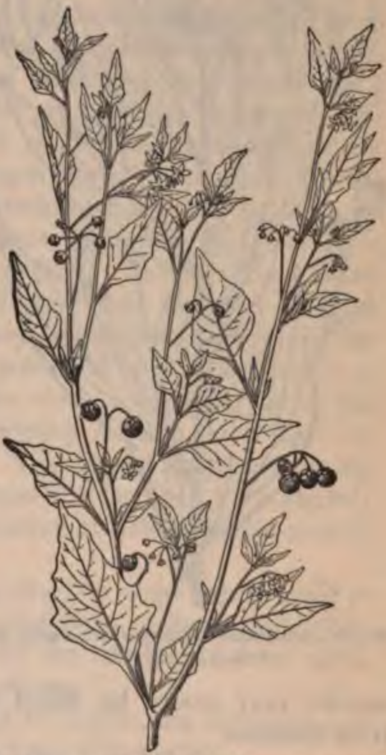

FIG. 23.—Black nightshade (*Solanum nigrum*), one-third natural size.

**oisonous properties.**—The amount of poison present in any part of this
nt varies with the conditions of growth. The more musky-odored
nts are the most poisonous. In some the amount of alkaloid in the
fruit and leaves is so small that these parts may be, and are, con-
ned in considerable quantity without any ill consequences. Poison-
does sometimes follow, but it is not clear whether this is due to

improper preparation or to careless selection of the parts used. The use of black nightshade for food is certainly not to be recommended. Cases of poisoning are recorded for calves, sheep, goats, and swine.

**Symptoms.**—The characteristic symptoms are about the same in man and animals. They are stupefaction, staggering, loss of speech, feeling, and consciousness; cramps, and sometimes convulsions. The pupil of the eye is generally dilated. Death is directly due to a paralysis of the lungs, but fortunately few cases are fatal.

Nearly related to this plant is the spreading nightshade or "wild potato" (*Solanum triflorum* Nutt.), a native garden weed of the Great Plains region. It is a smooth, low annual, with widely branching stems, 7 to 9 lobed leaves, numerous clusters of small white flowers which are grouped in threes, and large green berries a half inch or more in diameter. These are not attractive to the eye, but have an agreeable odor and taste.

Complaints of the poisoning of cattle by this plant have been sent in to the Department from Nebraska, and experiments show that the berries are poisonous. No cases of human poisoning have been reported.

The plants of either of these species may easily be killed by cutting them down before the fruit matures.

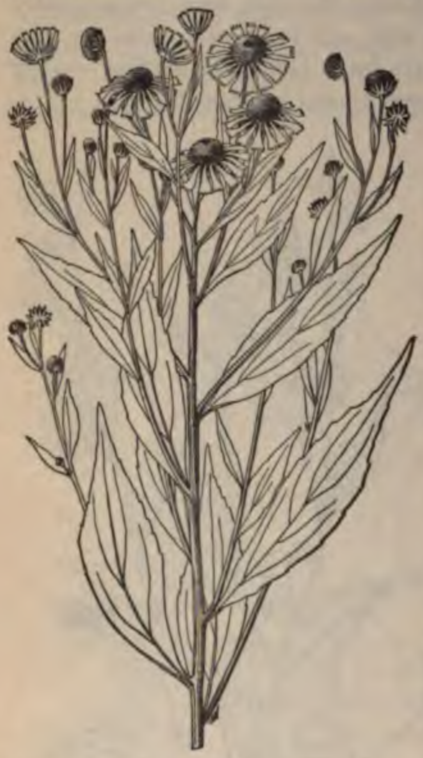

FIG. 24.—Sneezeweed (*Helenium autumnale*), one-third natural size.

### BITTERSWEET.

*Solanum dulcamara* L.

**Other names:** Woody nightshade; nightshade vine; staff vine; fever twig; tetonwort.

**Description and where found.**—A climbing, woody, introduced perennial 3 to 6 or 8 feet high, with thin leaves, the lowermost of which are ovate or heart-shaped, the upper more or less spear-shaped. The flowers are purple, the fruit red. It ripens from July to October and November. The plant thrives best and is common along brooks and tches from Massachusetts to Ohio, less common elsewhere in damp ound from Maine to North Carolina and to Wisconsin and Missouri.

**Poisonous property.**—The berry, though its taste is not remarkably isagreeable, is somewhat poisonous, and it has been shown that an xtract of the leaves is moderately so.

## SNEEZEWEED.

*Helenium autumnale* L.

**Other names:** Sneezewort; autumn sneezewort; autumn sneezeweed; taggerweed (S. C.); swamp sunflower; false sunflower. (Fig. 24.)

**Description and where found.**—A smooth, angular, branching per-nnial, 1 to 3 feet high, with rather thick lance-shaped leaves, and a arge number of showy yellow flowers which do not appear until autumn. It grows commonly in moist ground from Connecticut to Michigan and Illinois, and southward to the Gulf; less commonly northwestward from Louisiana to Oregon and Washington; also in Arizona. It has been found at an altitude of 6,000 feet in Nevada.

**Poisonous character.**—The whole plant, especially the flower, is bitter and more or less acrid and pungent. The powdered plant causes violent sneezing when inhaled, and it is therefore used in medicine to produce that effect. Sheep, cattle, and horses that are unfamiliar with the plant are often poisoned by it when driven to localities where it abounds. As a rule, these animals avoid it, but it is claimed that they sometimes develop a taste for it and are killed by eating it in large quantity. The poison exists principally in the flowers. The young plants appear to be only very slightly dangerous; in the mature ones the amount of poison varies greatly even in the same field.

**Symptoms.**—The symptoms, as determined by experiments made in Mississippi upon calves, are an accelerated pulse, difficult breathing, staggering, and extreme sensitiveness to the touch. In fatal cases, death is preceded by spasms and convulsions.

Sneezeweed may be best kept in check by cultivating the ground or by mowing the plants down before the time of flowering.

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U. S. DEPARTMENT OF AGRICULTURE.

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FARMERS' BULLETIN No. 93.

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# SUGAR AS FOOD.

BY

MARY HINMAN ABEL.

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[REVISED NOVEMBER 15, 1906.]

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PREPARED UNDER THE SUPERVISION OF THE OFFICE OF EXPERIMENT STATIONS
A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

# LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
*Washington, D. C., November 15, 1906.*

Sir: I have the honor to transmit herewith an article on sugar as food, prepared by Mrs. Mary Hinman Abel, in accordance with instructions given by the Director of this Office.

In preparing the article Mrs. Abel has made an extended study of the literature of the subject and has had the opportunity of discussing doubtful points with specialists in physiology and hygiene.

The work of the Division of Chemistry of the Department has been drawn upon, as well as the results of the nutrition investigations conducted under the direction of this Office.

The relatively small number of definite investigations regarding the food value of sugar which have been found is a matter of some surprize. There are a number of points concerning the actual food value of this staple article of diet which are rather matter of opinion than established fact. This emphasizes the need of experiments along these lines.

It is believed that this article is a useful summary of available information concerning sugar as a food, and its publication as a Farmers' Bulletin is therefore respectfully recommended. In revising the bulletin some recently published data have been summarized and included.

A. C. True,
*Director.*

Hon. James Wilson,
*Secretary of Agriculture.*

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# SUGAR AS FOOD.

## EXTENT OF THE USE OF SUGAR.

The pleasant flavor of sugar, together with what we now know of its nutritive value, will account for its great popularity as a food. It may almost be said that people eat as much sugar as they can get, and the consumption of sugar in different countries is, in general, proportional to their wealth.

The English-speaking people are the largest consumers of sugar. In 1895 England consumed 86 pounds per capita and the United States 64 pounds, altho still larger amounts are said to be consumed in sugar-growing districts, largely in the form of the ripe cane. Denmark and Switzerland consumed in the same year 45 pounds per capita, and Germany, France, and Holland about 30 pounds. Near the end of the list are Italy, Greece, and Turkey, with a consumption of less than 7 pounds per capita. The consumption of sugar is everywhere increasing. Seven to eight million tons are used annually in the different countries of the world.

## CHEMICAL COMPOSITION OF SUGAR.

By the term " sugar " as here used, is meant cane sugar, so called because it was first manufactured from the sugar cane, altho it is also found in the juice of a number of plants. Besides cane sugar there are a number of other sugars, as grape sugar, fruit sugar, and milk sugar. Considered chemically, all sugars are carbohydrates; that is, bodies composed of the three elements—carbon, hydrogen, and oxygen—the oxygen and hydrogen being in the same proportion as in water, which is made up of two atoms of hydrogen and one of oxygen. The principal carbohydrates which serve as food may be classified as follows: (1) Monosaccharids, including hexoses, such as glucose, or grape sugar, and levulose, or fruit sugar, made up of 6 atoms of carbon, 12 atoms of hydrogen, and 6 atoms of oxygen; (2) disaccharids, such as cane sugar and milk sugar, made up of 12 atoms of carbon, 22 of hydrogen, and 11 of oxygen, and (3) polysaccharids, such as starches, made up of 6 atoms of carbon, 10 of hydrogen, and 5 of oxygen, this combination being repeated an unknown number of times. It will be seen that the second group is twice the first minus the elements of water, and that the third is the same as the first minus water. When by chemical means water is added to the second group, it is separated into two hexoses, and when water is added chemically to group 3, two or more hexoses are formed. This process is called inversion, or hydrolysis, and may be produced in a number of ways. It is spoken of later. It will be seen that each group contains a number of different members; for example, grape sugar and fruit sugar have the same chemical composition. This does not mean that they are identical bodies. Their difference in properties is explained on the ground that altho they contain the same kinds of elements with the same number of atoms, the atoms are differently grouped. This must not be confused with the fact that the same sort of sugar may be obtained from widely different sources; thus, grape sugar is found in grapes and other fruits, and cane sugar is found in the juice of the sugar cane, beets, carrots, and other plants.

## CHARACTERISTICS OF CANE SUGAR.

In appearance pure cane sugar consists of a mass of white crystals. It dissolves easily in about one-half its weight of cold water and in still less of hot water. It is very sweet to the taste, two and one-half times as sweet as grape sugar.

At 320° F., which is considerably above the boiling point of water (212° F.), sugar melts into a colorless liquid which rapidly takes on an amber hue. If cooled at this point it hardens into a glassy mass, transparent and brittle, called "barley sugar." If heated still higher it browns, becoming less sweet and taking on a bitter flavor. This browned sugar is called caramel. Old-fashioned brown sugar owed its color and flavor, in part, at least, to caramel, for, as sugar was formerly made, in the process of evaporation over the open fire some of the sugar was caramelized, or half burnt, since in the final stages the mass became so thick that it could not move about freely and exchange heat, and the layer next to the bottom of the kettle was raised far above the boiling point.

## CHARACTERISTICS OF OTHER KINDS OF SUGAR.

As already stated, there are other sugars besides cane sugar. The one most frequently met with is dextrose, or grape sugar, which is much less sweet than cane sugar and differs from it chemically. It may be seen in yellowish grains in the raisin and is found in small quantities in other fruits. Dextrose chiefly occurs, however, as the result of the change known as inversion, which takes place in cane sugar, starch, etc., when heated in a solution with dilute acids or when treated in some other way to induce hydration—i. e., cause them to unite chemically with water. Cane sugar in this case splits up into a mixture of dextrose and levulose, known as "invert" sugar. The commercial glucose is dextrose made by hydrolizing starch.

ooks have often observed that more sugar is necessary in sweeten- acid fruits if it is heated with them from the first than if it dded when the cooking is completed. It has been claimed that is because some of the cane sugar, acted on by the heat and acid, been changed to those other bodies which are less sweet. The t of heat and acids in "inverting" cane sugar has constantly kept in view in the manufacture of sugar. By the slow methods erly in use on the sugar plantations the juice of the cane was dy sour when the boiling began, and these acids in the presence eat inverted much of the cane sugar, and the mischief was er increased because the very presence of glucose or of caramel solution of cane sugar renders the crystallization of the sugar difficult. The confectioner knows that if he wishes to prevent ncentrated solution of sugar from crystallizing, as in making ndant" or soft filling for bonbons, he has but to add a small portion of commercial glucose.

he change of cane sugar in solution to dextrose and levulose is ght about to some extent by the action of heat, even when no acid resent. It is also caused by the action of certain ferments, such as rtin, an enzym which occurs in connection with yeast, and by ents found in the intestinal tract.

**lucose.**—The liquid glucose, known sometimes as mixing glucose, ectioner's glucose, or corn sirup, is a thick, colorless substance n well made, and is prepared in large quantities by incompletely rolizing starch, usually by boiling with dilute hydrochloric acid, decolorizing and evaporating the product. Starch sugar or glucose is made in the same way, the starch or starch-containing tance being hydrolized until the greater part of it is converted dextrose. It is marketed in two forms, "anhydrous starch su- " and "hydrous starch sugar," the latter containing the larger unt of water of crystallization and being known as "brewers' ar" when it contains not less than 70 per cent dextrose and as sugar," "climax," or "acme sugar" when the dextrose content is less than 80 per cent. Altho not so sweet as cane sugar, pure ose is considered to be a perfectly wholesome compound pos- of a definite food value. Glucose, according to a publication he New Hampshire State board of health, enters to a greater or extent into the composition of practically all the cheap candy made. It is agreed that this form of sugar, aside from its pness, is much better adapted for certain candy-making pro- s than the more expensive cane sugar.

**ilk sugar.**—Milk sugar is another important sugar. Milk yields 4 to 5 per cent of this form, and it is not found elsewhere. said to be the most digestible sugar for infants.

**ney.**—Honey as stored by the honeybee was formerly very highly prized as a food and flavor. This is less the case since cane sugar has become so cheap and plentiful. In addition to very small quantities of cane sugar, honey consists of a mixture of glucose and levulose (about 37 per cent of each). Honey also contains water and a small amount of mineral matter. It owes its flavor to volatile bodies found in the flowers from which it is obtained, and this flavor varies according to the source from which the honey is gathered, that from some flowers having a more agreeable flavor than that from others. Honey has been used from the earliest times, and is generally regarded as wholesome in moderate amounts. Strained honey is very frequently adulterated with commercial glucose sirup and other materials. While there is no reason for assuming that the manufactured glucose, if properly prepared, is more harmful than the glucose found in fruits, it is a cheaper article, and the fraud consists in selling a low-cost article under a false name for a high price.

**Japanese ame.**—In Japan a sweet material called ame has been made since early times from glutinous rice or glutinous millet, sometimes from common rice and rarely from Indian corn or sweet potatoes, by converting the starch they contain into maltose by the action of diastase. Malt or sprouted barley is generally used to furnish the ferment. The cleaned grain or other material is soaked in water and steamed until the starch grains are broken open and easily accessible to the ferment. Powdered malt and water in proper proportion are added, and in six or eight hours the diastase converts the starch very largely into dextrin and maltose. The liquid is then filtered and evaporated to the desired consistency, which varies according to the season. One of the forms is a dense, clear, light-colored amber liquid not unlike the best commercial glucose in some of its physical properties. Another form is hard and not unlike white candy. Ame has been manufactured in Japan for the last two thousand years, and long before sugar was known it was a favorite flavoring for articles of food. Even at the present time it is sometimes used in place of sugar in cooking and is also a favorite food adjunct for invalids.

**Malt sugars.**—Several so-called malt preparations, some of them thick like sirup and others more of the consistency of candy, are on the market in this country at the present time, and if these are true to name they are doubtless similar to the Japanese ame in mode of manufacture and composition.

**Glycogen.**—Glycogen is a carbohydrate having the same chemical composition as starch. It has, however, different chemical properties. Glycogen is found in small amounts in muscular tissue, and more abundantly in the liver, where it may exist, indeed, in considerable quantity. It serves an important function in nutrition, being stored by the animal body as a reserve material.

## 11

### SWEET MATERIALS OTHER THAN SUGAR.

accharin is an extremely sweet material, which is manufactured arge quantities. It is, however, not a sugar, but is of an entirely erent chemical structure, being a benzene compound and not a ohydrate. Unlike sugar, saccharin is not broken down and util- by the body, and so is not regarded as a food. There are differ- es of opinion as to whether it is harmful or not in small quantities, all concede that its use by persons in health is neither necessary desirable. This drug is quite commonly prescribed in cases of betes to satisfy the craving for sweets, as it is believed to be less mful in such cases than the sugar which it replaces. It is so ensely sweet that only a very small quantity is required to flavor ery large quantity of food. The use of saccharin in canned vege- les and fruits, in bakers' goods, and in similar ways in the place all or part of the sugar is justly considered to be an adulteration.

here are a number of other compounds which, like saccharin, e a very sweet taste, but which are not in any sense sugars and of value as foods. Generally speaking, they are of interest only to chemist and physician.

### SOURCES OF CANE SUGAR.

ane sugar, sucrose, or simply sugar, as it is known to commerce in the household, exists dissolved in many vegetable juices. It is nd in the stems and roots of all the grasses, especially in the sugar e and sorghum; in fleshy roots, as the beet, carrot, turnip, and et potato; in the sap of trees, as the date palm and sugar maple; almost all sweet fruits, and in the nectar of flowers; but in only ew of these is the proportion of cane sugar large enough to make ofitable its separation from the other substances which these juices d in solution.

The manufacture of sugar as at present known is an art that has eloped from crude beginnings. Sugar is a staple article of food, t as is bread or meat, but few people realize that, unlike meat and ad, it has been a staple food for but a few generations. Only, eed, in the last half century has it been produced in such quantities at such a price as to bring it within the reach of all classes of ple.

### THE SUGAR CANE.

**istorical.**—The sugar cane is a gigantic jointed grass (*Saccharum inarum*), native in eastern India and China, numerous varieties which are now grown in the tropical and subtropical regions of h hemispheres. Sugar from the sugar cane was probably known China two thousand years before it was used in Europe. When rchants began to trade in the Indies it was brought westward with

spices and perfumes and other rare and costly merchandis
was used for a long time exclusively in the preparation of m
An old saying to express the loss of something very esse
"Like an apothecary without sugar." Greek physicians sev
turies before the Christian era speak of sugar under the
"Indian salt." It was called "honey made from reeds," an
be "like gum, white and brittle." But not until the middle
Europeans have any clear idea of its origin. It was confoun
manna or was thought to exude from the stem of a plant,
dried into a kind of gum. When in the fourteenth or fifte
tury the sugar cane from India was cultivated in northern A
use of sugar greatly increased, and, as its culture was extend
newly discovered Canary Islands and later to the West In
Brazil, it became a common article of food among the w
in 1598 Hentzer, a German traveler, thus describes Queen E
then 65 years of age: "Her nose is a little hooked, her lip
and her teeth black, a defect the English seem subject to fr
great use of sugar." By many the new food was still regar
suspicion. It was said to be very heating, to be bad for t
and even to cause apoplexy. Honey was thought to be mo
some, because more natural than the "products of forced in

### THE SUGAR BEET.

**Historical.**—The sugar consumed in this and other countr
1850 was nearly all derived from the sugar cane, but at th
time two-thirds of the sugar crop is from the sugar beet.
1863 and 1883 Germany, one of the leading beet-sugar-p
countries, increased its output 338 per cent. It would
seemed incredible that the kitchen garden should furnish a
the "noble plant" that had made the fortunes of Spa
English colonies, but the cultivation of the beet has in one g
shifted the center of the sugar industry from the Tropic to
perate Zone. This growth has been fostered by strange vi
in the fortunes of nations, as the commercial embargoes a
bounties of the Napoleonic wars and by the emancipation
in the British colonies, giving, as it did, a temporary chec
growth of the cane; but the real creators of the new indus
men of scientific training who solved certain botanical and
problems. The manufacture of sugar is now a chemical ind
much as is tanning and dyeing.

Marggraf, a chemist of Berlin, first discovered in 1747 th
with other fleshy roots, contained crystallizable sugar identi
that of the sugar cane. In 1799 Marggraf's pupil, Achard,
the subject before the French Academy, and in 1801 erected
manufactory for beet sugar. He had manufactured it on his

sia and presented loaves of refined beet sugar to Frederick Wil- III, of Prussia, as early as 1797, but the 2 to 3 per cent of sugar could be extracted by the methods then in use was too small for mercial success. A new stimulus was given by the sugar bounties apoleon in 1806, and methods were rapidly improved, especially rance. Two great difficulties were still to be met; the percentage igar present in the beet was small (5 per cent), and it was sep- d with great difficulty from the many nonsugar constituents, of them acrid and of very unpleasant taste. Science now came e rescue, and a beet was gradually developed having a larger per- ge of sugar and a smaller percentage of the undesirable impuri-

Barber says that in 1836 18 tons of beet root were necessary to uce 1 ton of sugar; in 1850 this quantity was reduced to 13.8; in to 12.7 tons, and in 1889 to 9.25 tons. From 5 per cent of r as found by Marggraf the sugar beet of good quality now con- s 15 per cent and more, 12 per cent being considered necessary for itable manufacture.

### THE SUGAR MAPLE.

**anufacture.**—The sugar maple of North America is also a source ucrose, the trees being tapt in the early spring to obtain the s it flows upward. The sap was formerly simply boiled down in kettles and used as molasses, or the evaporation was continued the sugar crystallized and the brown maple sugar was obtained. e gallons of sap yielded about 1 pound of sugar. Improvements e process have been devised. The sugar is now made more easily quickly by the use of evaporating pans, etc. Maple sugar or p commands a higher price than white sugar from the beet or cane is now used as a luxury because of its agreeable flavor, altho it is an article of regular diet in Lower Canada, as it was formerly ng the farmers of New England and other regions.

ccording to figures obtained from the report of the United States us for 1900, the total quantity of maple sugar produced in this ntry in 1899 was 11,928,770 pounds and the total amount of le sirup was 2,056,611 gallons.

this connection it is of interest to quote a paragraph from a book ten by the eminent Robert Boyle and printed at Oxford in 1663:

> ere is in some parts of New England a kind of tree * * * whose juice weeps out of its incisions, if it be permitted slowly to exhale away the flous moisture, doth congeal into a sweet and saccharine substance, and e was confirmed to me by the agent of the great and populous colony of husetts.

cane and sugar beet are, however, the only important sources ır (sucrose). Of the world's crop of 13,957,300 tons in 1905–6, 00 tons were made from cane and 7,265,200 tons from the beet.

## QUALITY OF SUGAR FROM DIFFERENT SOURCES

The methods used in the manufacture of sugar are all to th separating the sugar from the other constituents of the juice. word, the juice containing the sugar is exprest or extracted the cane, beet, etc., treated to remove the nonsaccharin sub which prevent crystallization, evaporated in a vacuum apparatu sugar crystallized, and the crystals separated from the molas centrifugals. The sugar thus obtained, known as "raw sugar," tains impurities from which it is separated by the processes of fining. The methods of manufacturing sugar have been desc in a previous bulletin of this series.[a]

The average composition of raw sugar from a number of dif sources is as follows:

*Average composition of raw sugar.*

| Source from which obtained. | Water. | Cane sugar. | Other organic substances. |
|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* |
| Sugar cane | 2.16 | 93.33 | [illegible] |
| Sugar beet | 2.90 | 92.90 | [illegible] |
| Sorghum | 1.71 | 93.05 | [illegible] |
| Maize | 2.50 | 88.42 | [illegible] |
| Palm | 1.86 | 87.97 | [illegible] |
| Maple | ........ | 82.80 | ........ |

Raw cane sugar from these various sources takes on in each the character of the impurities from which it has not yet been fr Thus the raw product of the sugar cane and sugar maple is plea in flavor, that of the beet acrid and disagreeable; the raw palm s or jaggary is of low sweetening power, because of the large am of invert sugar (dextrose and levulose, see p. 8) that has resu from fermentation and too high a degree of heat used in evapora it, while raw sorghum and maize sugar has each the characteri taste of its sirup. From all these raw sugars the pure cane sug saccharose, as known to the chemist, can be crystallized out, an every case the sugar is identical in chemical composition, app ance, and properties. By no chemical test can pure crystall saccharose or "cane sugar" from these different sources be di guished. There is a popular impression to the contrary, howe and it is often asserted that beet sugar has less sweetening powe that fruits preserved with it do not keep as well, but this can onl true of specimens that have been imperfectly purified.

Methods of refining raw sugar have been so improved in the few years that it may be truly said that few food substances ar y pure chemically as the best granulated or lump sugar. Blythe

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[a] U. S. Dept. Agr., Farmers' Bul. 52. The Division of Chemistry of thi partment has issued a number of bulletins concerning the manufacture of s from sugar cane, sorghum, and sugar beets.

f sugar is, as a rule, chemically pure. It is probably, indeed, the purest substances in commerce, and a large quantity may be burnt up without ing a trace of nitrogen and without leaving any residue. The only s that may be impure are the raw sugars.

**ulteration of sugar.**—Out of 500 samples of sugar examined sev- years ago by the Bureau of Chemistry of this Department[a] not was found to be adulterated. The present low price of cane r protects it from such attempts.

more recent publication of the Bureau of Chemistry[b] states sugars as a class, both the high and low grades as found on the et, are practically free from adulteration. During recent years, ver, it is pointed out, a product has been offered for sale to a ed extent which consists of a mixture of cane sugar with starch r (glucose) and saccharin, the latter being an artificial sweet- g material derived from coal tar.

here is a popular belief that granulated sugar is often adulterated white sand or finely ground rock and that pulverized sugar is monly adulterated with starch or lime dust. Cases of such adul- ion, however, have never been found by the Bureau of Chem- , and so it may safely be said that they occur rarely, if at all. a very simple matter to test sugar for the presence of such rials if their presence is suspected. Sugar is readily soluble ater, and the sand and mineral adulterants are insoluble. If onful of sugar is added to a glass of water and stirred, it will letely dissolve, while any sand or similar material will remain solved. If the water is warm, the sugar will dissolve more kly than otherwise, and care must be taken to continue the stir- for considerable time, as some of the very dry crystalline sugars olve rather slowly.

## FOOD VALUE OF SUGAR.

ur chief practical interest lies in the use made of sugar in the nal organism, or its food value. Within certain limits we can upon sugar as the equivalent of starch that has been digested and e ready for absorption. A mealy boiled potato or a lump of dry starch is, in fact, very near akin to a lump of sugar; and the to, like all forms of starchy food, must be turned into a kind ugar by the digestive juices before it can be absorbed as food he system.

e statement is commonly made that the food eaten by the aver- adult is at least one-half of vegetable origin, and analyses show

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[a] U. S. Dept. Agr., Division of Chemistry Bul. 13, pt. 6.

[b] U. S. Dept. Agr., Bureau of Chemistry Bul. 100.

that the nutrients of vegetable foods are very largely starch.
average of 87 dietary studies made in the United States shows
cent animal food and 55 per cent vegetable food. Starch fur
a considerable part of the heat and muscular power of the
Therefore starch or any food that will serve the same purpos
great importance.

To understand this better we must follow the course of
digestion. When starchy food, as a morsel of boiled pota
taken into the mouth it is at once acted on by a ferment con
in the saliva, and this action is continued by a ferment contai
the intestines. It is broken up into simpler chemical comp
and it finally reaches the blood and muscles as dextrose, a fo
sugar which can be burned to yield heat and muscular energy.
an excess of carbohydrates (sugar or starch) is consumed, th
trose in the digestive tract is converted in the liver to glycog
stored until required, being then, it is believed, reconverte
dextrose. More complex changes may take place which c
carbohydates consumed in excess into fat, which is also store
reserve material.

### DIGESTION OF SUGAR.

If a solution of cane sugar be injected into the blood, it i
out by the kidneys unchanged, showing that it is not fitt
assimilation. The change needed, however, is slight compare
that required for the digestion of starch; it is " inverte
changed into the simpler sugars as already described, an
change is brought about in the digestive tract by the age
enzyms or ferments of whose nature we know little. Whe
changed into the simpler sugars its function in the body is s
to that of starch after it has reached the analogous stage in dig

At the Minnesota Experiment Station the digestibility of
was studied with healthy men, 5 ounces per day being consu
part of a simple mixt diet. The sugar showed a high digestibilit
per cent of its total energy being available to the body, on an a
In general it increased the available energy of the whole rat
per cent and did not affect the digestibility of the foods with
it was combined. The protein of the ration was more econom
used than commonly, the nitrogen retention being increased
cent. It was pointed out in discussing these experiments that
value of sugar in a ration depends upon its judicious use and
bination with other foods."

### SUGAR AS A FOOD FOR MUSCULAR WORK.

Food must supply enough protein or nitrogenous material f
formation and repair of tissue and for certain other uses in the
and in addition sufficient nitrogen-free material to make up t

quired amount of energy necessary for heat and muscular work. Nitrogen-free material consists of fat and carbohydrates. In the ordinary diet the relative amount of fat and carbohydrates is usually regulated by personal preference. Fat will furnish two and one-fourth times as much energy as carbohydrates. Taking account of this fact it is immaterial on theoretical grounds which of these nutrients supplies the necessary energy, altho this is, however, not the case from the standpoint of hygiene.

The main function of sugar as found in the blood, whether resulting from the digestion of sugar or of starch, is believed to be the production of heat and energy. The proof has been amply furnished by experiment. By ingenious devices the blood going to and from a muscle of a living animal may be analyzed, and it is thus shown that more blood traverses an active or working muscle and more sugar disappears from it than is the case with a muscle at rest.

The question naturally arises, How does the sugar of our food differ from starch as a source of muscle power? The fact that we have in this manufactured article practically the same substance as that which results from the digestion of starch as found in vegetable foods at once suggests its substitution for starch to the advantage of the system, since it does not burden the digestive tract and less force is required for its digestion. To decide this question much careful laboratory work has been carried on since 1893, when Mosso, an Italian investigator, first examined the influence of cane sugar in lessening fatigue. This he did by the use of the ergograph, an instrument devised by him for testing the work done by certain muscles of the hand. He found, as a result, that sugar in the food, in not too great quantities and not too concentrated, lessens or delays fatigue and increases working power.

Prof. Vaughan Harley continued these experiments in Mosso's laboratory, using much larger quantities of sugar, with the result that the amount of muscle work was greatly increased by it. He compared the work he could do in twenty-four hours fasting with what he could do when taking 500 grams (17.5 ounces) of sugar dissolved in pure water, and found that on the sugar day he could do 61 to 76 per cent more work, or almost as much as on a full ordinary diet. When 9 ounces of sugar were added to the ordinary diet or to a meager diet, the gain in muscle power was also considerable. The effect, altho felt one-half hour after eating, was at its height in two hours. Very interesting also was the effect of sugar in delaying the natural coming on of fatigue, which has been found to occur between 5 and 7 p. m. If 3 or 4 ounces of sugar were taken a short time before this hour, the ordinary fatigue did not appear and work went on as usual.

The following year Doctor Langemeyer, working under the direction of Professor Stockvis, of Amsterdam, repeated these experiments with great care on several different persons, the work extending over a period of eight weeks. The ergograph, which recorded the amount of work done, was concealed from the person using it in order that he might not unconsciously influence the result, a caution not observed in Mosso's laboratory. Doctor Langemeyer obtained only negative results as to the effect of sugar on muscle work; an increase of muscle power occurred as often when no sugar was taken, or after a short rest, or after taking a drink of water.

At about the same time the Prussian war office authorized a test of Professor Mosso's results; the work was undertaken by Doctor Schumberg in Professor Zuntz's laboratory in Berlin, and the result was published February, 1898. The ergograph was used in this case also, and the subject of the experiment, who was entirely ignorant of its nature, was given daily, in addition to his other food, 200 grams of a sweet fluid, which on certain days was a solution of 30 grams of sugar and on other days was water made equally sweet with dulcin, a sweet-tasting chemical having no food value. By this precaution it was hoped to eliminate the influence which may have affected the results of Mosso and his pupils, even against their will. The results seemed at first to corroborate those of the American laboratory, and thus to deny any immediate effect of sugar in increasing muscle power. When, however, the subject of the experiment performed some very exhausting work, as with a lathe, before beginning on the ergograph, the difference in the effect of dulcin and sugar became very apparent, the sugar restoring to some extent the efficiency of the tired muscle, while dulcin did not. The explanation given was that a little more or less sugar in the blood was of no consequence in ordinary exertion, but it was otherwise when the sugar stored up in the muscles was heavily drawn upon by exhausting labor. At such a time the rapidity with which sugar is digested and absorbed proves a great advantage.

In effect Doctor Schumberg says: "The practical conclusion to be drawn is that sugar in small doses is well adapted to help men to perform extraordinary muscular labor." He advises practical tests of his results on a large scale in which small amounts of sugar in some refreshing drink, as lemonade, will be given to men fifteen or twenty minutes before they begin a piece of very hard work or at the first signs of exhaustion. If the sugar is to be taken in solid form he recommends chocolate as the best medium. The application of these results to the food of soldiers who may be called upon for extraordinary exertion in marching or fighting is very evident.

Following on this work of Schumberg's came a practical test made with soldiers of the German army during the autumn maneuvers, the observation extending over thirty-eight days. A number of men were given 10 lumps (70 grams, or about one-sixth pound) of sugar daily and were compared in various ways with men performing the same amount of work in marching and drilling, but whose food contained little or no sugar. The results were in every way to the advantage of the men using sugar. The sugar was relished during the whole time. On long marches it appeased hunger and mitigated thirst; a feeling of refreshment followed, which helped the tired man on his way, and none of the soldiers allowed sugar were at any time overcome by exhaustion. It was found that both their pulse rate and breathing were less affected by exertion than was the case with the men consuming no sugar. On the basis of these results the military surgeon making the investigation recommended that the sugar ration for soldiers be raised to 60 grams daily, and that it be furnished as sugar for coffee and in sweetened food, preserves, or honey. It was recommended, further, that sugar be supplied to prisons, hospitals, and ships, its fine keeping qualities and condensed form making it especially valuable in certain cases. The value of glucose as a muscle food has been recently shown by methods similar to Schumberg's.

It is believed that more satisfactory results may be obtained by experiments with men and animals in which the effects of given quantities of sugar in the diet are compared with those obtained with starch and other food materials. Such experiments with men in the respiration calorimeter are now being made under the auspices of this Department. They make it possible to measure with great accuracy the relation between the material consumed and the muscular work done.

According to our present knowledge, the value of sugar as a food for muscular work may be briefly summarized as follows:

(1) When the organism is adapted to the digestion of starch, and there is sufficient time for its utilization, sugar has no advantage over starch as a food for muscular work except as a preventive of fatigue.

(2) In small quantities and in not too concentrated form sugar will take the place, practically speaking, weight for weight, of starch as a food for muscular work, barring the difference in energy and in time required to digest them, sugar having here the advantage.

(3) It furnishes the needed carbohydrate material to organisms that have as yet little or no power to digest starch. Thus, milk sugar is part of the natural food of the infant.

(4) In times of great exertion or exhausting labor, the rapidity with which it is assimilated gives it certain advantages over starch.

This latter quality, which renders it more rapidly available for muscle force, may, perhaps, account for the fact that sugar is so relished by people who are doing muscular work and by those of very active habits, as children.

The American farmer ranks high among agriculturists as a rapid and enduring worker, and his consumption of sweets is known to be very large. The same is true of lumbermen and others who work hard in the open air. Col. Henry Browne, quoted by Doctor Harley, says:

> The lumbermen of Canada, than whom no finer or more muscular men exist, eat a great deal of sugar in the form of molasses. They fill their milkless tea with it, make cakes with it, and even add it to their fried fat salt pork, which is the only meat they get during the whole time they are in the woods cutting lumber, and this is practically half the year, their diet when at home being much the same.

Sugar and sweet cakes, etc., are indeed often mentioned as favorite foods of lumbermen when engaged in severe work. Dietary studies carried on in the winter lumber camps of Maine by Woods and Mansfield showed that large quantities of cookies, cakes, molasses, and sugar were eaten, sugar of all sorts supplying on an average 10 per cent of the total energy of the diet.

In connection with the nutrition investigations carried on by this Department the dietary of the negroes in Alabama on the edge of the so-called "black belt" was studied. The staple articles of diet were found to be salt pork, corn meal, and molasses. The molasses was made from sorghum or sugar cane. It was often a domestic product. When this supply was not sufficient, a commercial molasses was purchased. Molasses was eaten mixt with the fat obtained when fat salt pork was fried. This mixture, with corn bread and fried pork, formed the basis of the regular diet for each meal every day in the year, some green vegetables being occasionally added. Hot water sweetened with molasses was the beverage used with the meals. It should be added that this diet was not considered satisfactory by those making the investigation, it being deficient in nitrogenous material.

The value of sugar in cold climates, where foods containing starch are not produced or can not be kept, is evident. In the outfit of polar expeditions sugar is now given an important place, and it may in time take the place of part of the large amount of fat eaten by the Eskimos and other inhabitants of the polar regions.

Oriental races are very fond of sweets, as often noted by travelers. Certain forms of confectionery are very popular in Turkey and other regions of the East, and in all tropical lands the consumption of dates, figs, and other sweet fruits is very large. In a recent discussion[a] of the food of the natives of India the great value set on the sweetmeats or sugar by the Hindoo population of all classes is pointed out. Large quantities of brown or white sugar are used to sweeten e boiled milk, which is a common article of diet, and sugar is also sed with sour milk, rice, cream, cheese, and other foods.

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[a] Jour. Trop. Med., 9 (1906), p. 310.

It has also been said that the employer who will not furnish the ative laborers with the large amounts of sugar they desire in their aily ration must expect to lose his workmen.

Certain rowing clubs in Holland report very beneficial results from e use of large amounts of sugar in training. It seemed to counter-ct the bad effects of a meat diet, so that the dreaded symptoms of vertraining did not appear. The rowers who used sugar always on because of superior endurance.

One case as given in detail is very interesting. Two schoolboys, 17 nd 19 years of age, with only two hours a day for practise, at the nd of two months entered for the rowing races. No change had been ade in their diet except that they ate as much sugar as they wisht, ometimes as much as one-third of a pound at the time of their daily xercise. One of them, however, did not make this addition to his iet until the third week, when he began to show all the signs of vertraining—loss of weight, and a heavy, dull feeling, with no esire for study. On the third day after beginning the use of sugar ese symptoms disappeared. At the time of the race both youths ere in fine condition and were victorious over their antagonists, ho did not believe in the use of sugar. No after bad effects were served.

Professor Pflüger says that, without doubt, the sugar in the blood heavily drawn on during violent exercise; hence the longing for it a form that can be rapidly assimilated.

Mr. Charles E. Courtney, trainer of the Cornell University boat ew, recently informed the writer that the men in training seemed to ave sugar, and they were allowed all they wanted on cereals, in tea, ffee, etc., but he objected to it in pie and cake.

Its use by mountain climbers is well known. The Swiss guide con-ders lump sugar and highly sweetened chocolate an indispensable rt of his outfit.

Sir Martin Conway, who has had a great deal of experience in ountain climbing, states that he has found a quarter of a pound of gar per man per day of advantage for this kind of work.

### SUGAR AS A FAT FORMER.

Sugar, like starch, is fattening; that is, when taken in excess it ay be transformed into fat and stored as reserve material. On this count physicians advise that sugar be sparingly used by the corpu-nt.

Both molasses and sugar have been successfully used in fattening ttle and pigs, the fat being found to be firm and of good quality.

### SUGAR AS A FLAVOR.

As mixt with other foods, sugar is one of our best flavors—a flavor which the cook could not readily spare, as it now enters into a great variety of dishes. Its agreeable flavor has always constituted one of the chief reasons for its use, and will continue to do so, since we have such an abundance of relatively cheap starchy materials which may readily take the place of sugar as food.

In some dietary studies made under the auspices of this Department with a club of students at the University of Maine, the effect was studied of supplying a liberal amount of maple sirup in connection with a diet which was known to furnish an abundance of nutrients. The sirup was evidently relished, and considerable amounts were eaten. However, there was not a corresponding decrease in other foods; on the other hand, the amount of flour was in excess of the amount ordinarily consumed. It would seem that the maple sirup and flour, in the form of griddle cakes, were consumed simply on account of their agreeable flavor. Provided the diet contained sufficient nutrients in the first place, this increase was not desirable on the ground of economy, and it may be questioned whether it was desirable from the standpoint of health. When a similar comparison was made of the addition of milk in liberal amounts to the diet it was found there was a corresponding decrease in the amount of other foods consumed.

This investigation would indicate, as stated above, that sugar is consumed for its agreeable flavor and not because it is recognized as a food.

### FOOD VALUE OF TABLE SIRUPS AND MOLASSES.

Sirups of various kinds and molasses have always been used to a large extent in the United States as articles of diet and for cookery. There are several forms in common use; of these, maple sirup, which is obtained by evaporating the sap from maple trees, commands the highest price in the market. Another very abundant table sirup which is in common use is made from sorghum by methods very much like those used in the manufacture of sirup from sugar cane.

The sirups and molasses of different grades obtained as by-products in the manufacture of sugar from sugar cane have always been popular. Besides some cane sugar molasses contains about 30 per cent invert sugar, 30 per cent water, and some acids and other less important bodies. Before the advent of the vacuum evaporator and strike pan large quantities of sugar were inverted in the process of boiling in the open kettle. Moist sugars resulting from this process were, after crystallization, placed in hogsheads with perforated bottoms, thru which the molasses flowed out. Such molasses was highly appreciated and for a long time was a staple article for table use and for cookery. The modern process of sugar making has, however, practically eliminated this open-kettle molasses from the market. To supply its place the manufacture of sirup directly from the sugar cane and without the separation of any kind of sugar has come to be practised recently to considerable extent in the South, particularly in the South Atlantic and Gulf States.

According to H. W. Wiley,[a] of the Bureau of Chemistry of this Department, "this sirup forms a delicious, wholesome, and valuable condimental food substance, the use of which is rapidly extending; and, because of its merits, it appears destined to become a very important food."

For some reason the public has come to judge sirup largely by its color, and a light-colored sirup has been preferred to one with a deeper tint. The fact has apparently been lost sight of that if properly manufactured good sirup must possess a decided color. This depends upon the fact that in the commonly accepted method of manufacturing sirup by evaporation in an open kettle a high temperature is employed, which causes an inversion of some of the sugar and prevents crystallization. The high temperature also produces caramel, or coloring matter, from the sugar and imparts a color to the sirup of greater or less intensity. The caramel has a decided flavor and so improves the taste of the product. Color, therefore, should be an indication that the sirup has been manufactured in the proper way and should not be regarded as a detriment.

As pointed out in the article on table sirups referred to, there are also in use in this country quantities of table sirups which are simple mixtures, the chief ingredient of which is glucose, and they may or may not contain some of the sirups and molasses above mentioned. Mixt sirups, which owe their flavor and color to the molasses which is a final by-product of the sugar refinery, contain so much soluble salts that they have a distinct saline flavor and also more or less of the flavor which is derived from the boneblack which is used in purifying the sugar. Many of these mixt sirups and molasses are placed on the market under their true names, and in this condition are unobjectionable. Others are sold as genuine sirup or molasses and to this extent are fraudulent.

No molasses for table use is made from the sugar beet, as it is impossible to free the uncrystallizable part from the objectionable impurities. Maple sirup or molasses is the sap of the sugar maple which has been boiled down, but not sufficiently to cause the sugar to crystallize. The high price of maple molasses or sirup has led to

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[a] U. S. Dept. Agr. Yearbook 1905, p. 241.

extensive adulterations of the product with cane sugar and
the flavor being often furnished by an extract of hickory

### NUTRITIVE VALUE OF SUGAR CANE.

The entire juice of the ripened cane is of course more ne
complete food than is crystallized sugar, for it contains othe
stituents besides carbohydrates. It is elaborated by the pla
a rich plant food used to build up young leaves and buds
sugar-producing countries the cane is said to be a staple food d
its season. All classes of people chew the ripe cane freed
its hard rind, incredible quantities being consumed in this
Shiploads are brought daily to the markets of Rio Janeiro,
Orleans, and West India towns. For months the chief food o
negro laborers on the plantations is said to be the sugar cane
they are seen to grow strong and fat as the season advances.
go thru the hard labor of harvesting the crop and come out in
condition, altho they began it weak and half starved.

Wray says: "The nutritious and fattening qualities of the
cane are abundantly shown on every sugar estate in the w
Another writer says: "From their free use of the cane juice th
groes of the West Indies and every animal about the plantati
the time of harvest show every indication of the wholesome and
tious properties of the juice."

A curious book, entitled "A Treatise on Sugar," written by
Mosely, and published in 1799, has the following:

> In the West Indies the negro children from crude vegetable diet ar
> afflicted with worms. In crop time, when the canes are ripe, these child
> always sucking them. Give a negro infant a piece of sugar cane to su
> the impoverished milk of his mother is tasteless to him. This salubrio
> ury soon changes his appearance; * * * his emaciated limbs increa
> If the canes were always ripe he would never be diseased. I have ofte
> old, scabby, wasted negroes crawl from the hot houses, apparently hal
> in crop time, and by sucking canes all day long they would soon become
> fat, and sleek.

La Gazette de Santé, 1785, narrates that a vessel from the
Indies laden with sugar encountered a calm, which so delaye
that provisions were exhausted. The crew then had recourse
cargo; some sailors had already died of scurvy and many were
ened with death, but this disease abated when its victims w
necessity reduced to a sugar diet. The sugar in this case w
doubtedly raw or crude sugar, and it may well have had this ef
virtue of the potassium salts contained in it.

### SUGAR AS A FEEDING STUFF.

The value of sugar as a foodstuff is shown by the extent to
in the form of molasses it is now used in the feeding of farm a

gar-producing regions it is a common constituent of the rations
rses and mules, and is fed to dairy cattle and to fattening steers.
ouisiana it is a usual practise to feed plantation horses and
s 8 to 12 pounds per head per day of " black strap " molasses.
ommon has its use become for farm animals as a whole that
y mixt rations are now on the market which contain molasses as
of their chief constituents. Sometimes the materials added are
principally to absorb the molasses and make it more convenient
ed. The molasses, of course, contains practically no protein,
frequently materials are mixt with it which are rich in this
ituent in order that the mixt feed may constitute a well-balanced
n.

## PRACTICAL USE OF SUGAR IN DIETARIES OF ADULTS.

gar was formerly regarded as a condiment and valued chiefly
s pleasant taste. Had it in reality no other use it might in time
laced by other sweet-tasting substances, as saccharin and dulcin,
are not foods, but the food value of sugar has been fully estab-
l, and, considering the immense quantities at present consumed,
very important to determine the extent of its usefulness in
ries.

has been ascertained that in large numbers of well-to-do families
r country about 2 pounds per week per person is consumed. It
d seem that this amount, or about one-fourth of a pound daily,
as it is in connection with other foods, is well utilized by the
m. Regarding larger quantities there is some question. The
f sugar would seem to be limited in two ways: (1) By the fact
sugar may be absorbed more rapidly than it can be assimilated
hus overload the system, bringing on indigestion or overloading
xcretory organs; (2) by the ill effects on the system of concen-
d solutions of sugar.

### AMOUNT AND CONCENTRATION.

garding the amount that can be properly used in the system,
r differs greatly from starch. Starchy food, as bread, potatoes,
can be digested and utilized in immense quantities. Rubner
rts that food containing over 600 grams (1.3 pounds) of starch
y is digested without difficulty and over considerable periods of
. This amount of starch would be represented by 2.5 or 3
ds of bread or 6 or 7 pounds of potatoes.

wer tests have been made regarding the maximum amount of
r that may be used by the system. Vaughan Harley used large
tities of sugar in his experiments already quoted, but 400
s (nearly a pound) daily for some time very much affected his
tion.

Since, as scientific investigators seem agreed, the dig sugar is much more rapid than that of starch, assimilation an in the liver can not keep pace with its absorption in the int it is taken in large quantities. In this case part of the su be excreted unchanged. Not only is this excess of sugar wa such an unnatural tax on the excretory organs would soo disease. It is also a matter of common observation th amounts of sugar and sweetened food are apt to fermen stomach and intestines. This prompt refusal of the system large amounts of sugar at a time is a sign that must be hee shows that the eating of sugar can easily be carried too far.

It has been pointed out by investigators that in this rega bears much the same relation to starch that peptone, on products of meat digestion, does to meat. Both sugar and are very diffusible, and thus enter rapidly into the cir strong solutions at the same time irritating the mucous m with which they come into contact by virtue of their water-ab power. In cases of weak digestion peptone and albumoses, artificially digested, is given, that the system may be nouris as little tax as possible on the digestive organs. But in th a man in health, if the peptone is substituted entirely for th food, it brings on irritation of the intestinal canal, with dia other symptoms of indigestion.

Brandl, a German scientist, made experiments on the sugar solutions of different strengths on the stomach of a solution of 5.7 per cent reddened the mucous membrane; cent solution made it dark red, indicating great irritation; cent solution caused the dog such distress that the experi carried no further. It is quite possible that this effect is on the human stomach when large quantities of sugar in trated from, as candy, are eaten.

Chaveau, a French investigator, in his experiments with do that when used in considerable amounts sugar was so laxati effects as to interfere greatly with his work; yet he found, others, that sugar was a source of energy, and his conclusion it has a higher value as compared with fat than is ordinarily to it. It must be remembered that sugar is a powerful anti germicide. In a strong sirup of sugar fruits, vegetables, meats may be preserved. This property of sugar was wel stood when it was used only as a medicine, for it was even on wounds to keep them from mortifying. An agent of thi concentrated solution must not only hinder putrefactive but also retard the process of digestion. Thus, Ogata foun periments with dogs that the addition of 10 grams of cane

ar to 100 grams of meat fibrin caused 18 to 27 per cent of it to
ain undigested as compared with normal digestion. With our
ent understanding of the amount of absorption going on in the
ach, we can not state positively that such a delay is in itself
dvantageous.

will be noticed that sugar as it exists in nature—e. g., in the sugar
, in milk, and in most fruits—is not highly concentrated. In
it makes up from 4 to 6 per cent. It would seem that the
al organism is best adapted to the utilization of food principles
he somewhat dilute or bulky form in which they occur in the
monly accepted foods—protein as found in meat, milk, etc., starch
rains, and sugar in small quantities as found in vegetable juices
milk and in reasonable amounts in combination with other
ds—and that it does not readily accept unlimited amounts of
mically isolated and purified food principles.

### BAD EFFECTS ASCRIBED TO SUGAR.

Most of the bad effects ascribed to sugar are due to its use in larger
ntities than the 3 or 4 ounces a day which seem to be digested by
healthy adult without difficulty, if it is not presented in indi-
tible forms. It is not true that sugar is harmful to the teeth,
ho doubtless sweet food, allowed to cling to the teeth after eat-
g, rapidly ferments, and acids will be formed that, according to
ofessor Miller, of Berlin, may attack the teeth. This is equally
e of starchy foods. It is said, however, that the negroes of the
est Indies, who consume enormous quantities of sugar, have the
est teeth in the world.

It is also unproved that sugar produces gout.

Sugar seems ill adapted to the sick, except when used in very small
ntities as a flavor. Jacobi remarks that in sickness the stomach is
ctive, has less absorptive power, and that sugar on that account is
s well borne. The action of sugar in stimulating a flow of the
estive juices may in such a case be only irritating in its effect.

### ECT OF EXERCISE ON THE AMOUNT OF SUGAR WHICH MAY BE EATEN.

The amount of sugar that may be eaten without bad effects depends
ch on whether a person leads an active or a sedentary life. It has
n observed that a man doing hard work in the open air can easily
similate large quantities of sugar, while the same quantity would
ng on indigestion if taken when he is living indoors, with little
ercise.

## SUGAR IN FRUITS.

As pointed out by the California Experiment
of a large number of studies of fruits and fruit
value of fruits is due, in large measure, to the
sorts which they contain. The principal sugar
sugar, grape sugar, or glucose, and fruit sugar,
two being usually present together in equal quan
as invert sugar or reducing sugar.

The stage of growth and the degree of ripeness
effect on the kind and amount of sugar present
therefore difficult to give average figures which
the quantities present. According to figures pub
ago, invert sugar ranged from 2 per cent, in roun
early apricots to 15 per cent in grapes and a varie
while strawberries, gooseberries, raspberries, an
about half the latter quantity. The cane sugar ra
1 per cent in lemons to 14 per cent in a variety
nanas were also found to contain a fairly high
11 per cent.

Dried fruits like figs, dates, and raisins, which
trated by evaporation, naturally contain much
of sugar than fresh fruits, the amount of grape s
ing sometimes over 50 per cent. The use of su
sweetening cooked breakfast cereals and other di
uncommon.

Jams, jellies, and similar products very comm ight to be harmless, while regarding others there is more doubt. hundred and fifty samples of cheap candy examined by the Di- on of Chemistry of this Department a few years ago were found e made up largely of glucose with a little sugar and starch. glucose is no longer considered an injurious adulterant. Some e coloring matters and flavors used, however, have been shown harmful. Ordinary caution would suggest that children, at be allowed to partake very sparingly of such unknown com- ds. It is to be remembered also that glucose, being more rap- absorbed than is cane sugar, may overload the system more y. It also undergoes fermentation more readily.

### SUGAR IN THE DIETARIES OF CHILDREN.

he amount of sugar to be given children, and in what form, is a tion of much importance. Sugar would seem to be a food espe- y adapted to children because of their great activity. The small anism loses more heat from the skin for every pound of body ght than does the larger animal, and children on this account, and use of their active life, require proportionally more heat units in food than do adults.

t, especially fat meat, which could readily supply this need, is disliked by the child, and his relish for all kinds of sweets has btless a physiological basis. It is, however, to be remembered before its introduction countless generations of children had been ed without the help of cane sugar as we now know it. The diges- lity of sugar and sweetened foods for children, and the influence he appetite for other foods, must decide to what extent sugar is eplace starch in the dietary and how far it may be safely used as avor.

ntil a child's stomach is capable of digesting starch the needed bohydrate is furnished in the sugar of milk, the child a year who drinks two quarts of milk a day taking in this way about 3 ces of sugar. As the stomach becomes able to digest starch the d is less and less dependent on the sugar of milk, replacing it with carbohydrates of vegetable origin, while the proteids and fat nd in eggs, meat, and cereals take the place of those constituents were at first exclusively furnished in milk. Milk, however, ains thru childhood a valuable source of all these food principles.

he fact that sugar has a high food value is not the only point to considered. The child will easily obtain the needed carbohy- ates in other forms and will thrive if the digestion remains sound ts relish for wholesome food unimpaired. For instance, one hears it said that a certain child does not relish milk. In such it might be found that the child's appetite, being sated by

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 94.

# HE VEGETABLE GARDEN.

BY

CHARLES H. GREATHOUSE, A. M.,
*Division of Publications.*

WASHINGTON:
GOVERNMENT PRINTING OFFICE,
1899.

# LETTER OF TRANSMITTAL.

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U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF PUBLICATION
*Washington, D. C., March*

SIR: I have the honor to transmit herewith for publication as a Farmer an article entitled The Vegetable Garden, prepared by Mr. C. H. Gre this Division. There has long been a demand for information on garden the present bulletin aims to give in a few concise suggestions in regard t tion and care of the most common vegetables, whether in the farm garde less pretentious garden plot of the city or suburban resident.

In the preparation of the bulletin this Division has been greatly ai William Saunders, Superintendent of Gardens and Grounds, who kindly a author the benefit of his wide experience. When completed, the bulleti mitted to him and has received his approval. Much help has also been g Prof. L. H. Bailey's book, Garden-making.

Very respectfully,

GEO. WM. HI

Hon. JAMES WILSON, *Secretary*.

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Importance to farmer
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# THE VEGETABLE GARDEN.

## IMPORTANCE TO THE FARMER.

e farm garden probably pays better than any other land on the e. No figures have ever been collected to show of what value its ucts are, but in the census of 1890 full statistics for market gar- were obtained and from these the conclusion just stated may be ed. The average value of garden stuff to the acre was found to be .17, while for wheat the average was only $11.65. Later reports that the average for wheat, corn, oats, and hay is $7.75 per acre. ems clear, therefore, that market gardening is more profitable than ing. But the home garden must pay even better than the market en, for it is not subject to the heavy losses incident to marketing shable crops. Its products are used directly on the home table there need be very little waste. It follows that the garden pays er than the field. A good garden will supply half the family's liv- and when field crops show a balance on the wrong side it becomes ry important means of support.

addition to this the garden may be a bountiful source of quiet sure. A keener appreciation of such natural joys of the farm home skill to develop them would do much to repress the craving for tement which draws young men from country life.

## LOCATION.

e garden is frequently under the care of the farmer's wife. It ld be in such case as near as practicable to the kitchen, so as to be sy reach for gathering the vegetables and for fifteen-minute oppor- ties for gardening. Also all heavy crops, as potatoes, melons, sh, and cabbage, must then be put in the field, where they can be ivated with horse and plow.

urther, the site should be chosen with reference to sun and wind. urface that slopes gently to the south is to be preferred, and if the ine looks a little to the east it is the better for it. A woodland or h hill as protection from the north winds and heavy storms is a great antage, and equal or better will be a wall or hedge judiciously ed as a wind-break. It should usually be on the north or north- in this country. A wire netting or high paling fence will be ed to keep out the chickens, if any are on the place.

as open as sand and well adapted to growing vegetables. Bu
breaking is left till spring, or if the ground broken in the f
become compacted during the winter, the plow should be set de
harrowing and rolling continued until a fine, loose condition is se
As a rule, two plowings will be better than one and three bette
two. Prepare the soil thoroughly before planting. Neglect
will be felt all through the season. After the plants are growin
too late to work the ground beneath them.

The time to plow in the spring is as soon as deep freezing has
and the ground is in condition to be worked. The proper conditi
working can be determined by squeezing a little of the soil in the
If it makes a ball, and sticks to the hand, it is too wet; if it
hard, it is too dry. T
well, either for plow
hoeing, it should c
easily and finely, and
very little dirt on the

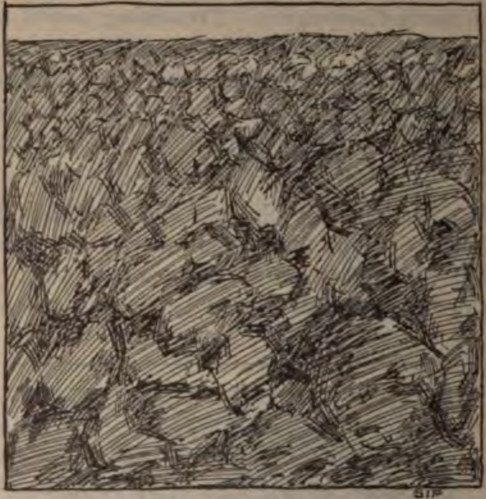

Fig. 3.—Vertical section of soil poorly prepared.

## USE OF FERTILIZ

Of leading importa
preparation of the gro
the supply of plant f
which the chief ess
are nitrogen, phosp
acid, and potash. It
portant that any fe
used to supply the
ments should be thor
distributed through
soil to be reached b
roots of the plants, an
distribution must be completed before planting. Turning and retu
the ground and harrowing again and again are useful for the pur

A wise selection of fertilizers can not be secured by rule; it i
largely a matter of experience. A sandy soil is often deficient
essentials of plant food, while a clayey soil contains them in abund
especially potash. A limestone soil is likely to contain a conside
proportion of phosphoric acid. What is good fertilization on a give
for one crop may be very unsatisfactory for another. Where it i
purpose to establish a garden permanently, it will be profitab
determine the need of the soil for fertilization by close observati
results from year to year. It will be well to make notes of imp
points. Not only will the facts thus gained be useful for futur
dening, but they will often find application in the larger operati
the field.

Most soils are benefited by the addition of humus, a name appli thoroughly rotted vegetable or animal matter. Humus may be n by burning a small quantity of soil on a red-hot shovel. If it an odor of feathers, it contains humus from animal matter; if an of straw, it contains humus from vegetable matter. Humus s the richness of nearly all good land, and rarely is there too much

In close-grained, sticky soils, which have a tendency to bake, umus produces a looser texture and a better balance in the reten- of moisture. On a loose and leachy soil it brings the grains closer her and promotes chemical activity. At the same time it supplies food. Leaves, garden refuse, and barnyard manure made into a ost and allowed to decay make good humus. The pile must be ed over several times each year until it is thoroughly broken up a mass of even texture.

me may be very often added to a soil with good results. It cor- acidity, makes clay soil more friable, and holds sand closer ther.

e time for putting on fertilizers depends upon the character of the nd of the fertilizer. Stable manure may be spread evenly over urface a short time before the first plowing. It is generally stated manure should be thoroughly rotted or "short" when applied, but considered a good practice to haul it directly from the stable g the winter and scatter it on the ground where it is to be used. is way the liquid portions are more fully available. The principal ntage in rotting manure before applying it is that the rough litter, traw, etc., is well broken up, and so the mechanical condition of soil is improved by its application. The crop to be grown must be considered in determining how thoroughly rotted the manure ld be. It must be remembered that it takes more time for vege- tissue to be broken up than it does for animal tissue.

ood ashes are a common and ready source of potash, and in addi- improve the mechanical condition of most soils. The lime in them s to correct "sourness" and to promote the important chemical ess of nitrification. Ashes are usually found to render light, sandy more moist. Cotton-hull ashes are also very useful, furnishing sh and phosphoric acid.

valuable means of improving the soil is by growing clover and eas and turning them under. Benefit is also derived by growing and beans and other leguminous plants. They collect nitrogen t their roots and it is left in the soil.

me commercial fertilizers are harmful to certain crops, and care be taken by inexperienced persons that a wrong use is not made em. Chemical fertilizers may be applied much nearer the time at h they are to be used by the plant. Bellair, a French authority, for deep-rooted plants, fertilizers should be put on in the spring e breaking the ground; for shallow-rooted plants, after breaking. ller details as to improvement of soil may be found in the following Farmers' Bulletins: No. 21, Barnyard Manure; No. 44, Commercial Fertilizers; and No. 77, Liming of Soils.

## SUPPLY OF SEED AND YOUNG PLANTS.

Seeds should be ready by the time the ground is prepared. It is usually considered enough to send to some reputable dealer and depend upon him for quality. But it is so important to have good seed and mistakes are so easy that careful examination of the seed some time before planting is advisable.

### QUALITY AND QUANTITY.

It has been found by experiment in the Department of Agriculture[1] that large, heavy seeds produce stronger plants than do small, light seed. It is always a mistake to plant old seed, and often it is well to procure a supply from a different part of the country, but not very remote nor too different in climate. In this way the tendency of cultivated plants "to run out"—i. e., to go back to the wild state from which they have been improved—is counteracted. Seeds of weeds that are hard to kill out are sometimes found in field and garden seeds and precautions must be exercised against them.

The quantity of seed to be used will depend of course upon the amount of ground to be planted, and that again varies with the size of the family and their preferences among vegetables.

A quantity necessary to sow a fixed length of row is stated at the end of directions for soil and cultivation of various vegetables as given on page 15 and following. Reference to this will be helpful in determining how much seed to provide. It is better to have too much than too little.

### PLANTS FROM THE HOTBED.

Many vegetables, as tomatoes and cabbage, must be started in the hotbed and the plants reset once or twice. Such plants can usually be purchased of seed dealers or experienced gardeners in the neighborhood. Enough for a small family may be started in a good-sized box of earth in a south window. But a hotbed (fig. 4) and cold frame are not hard to make. They should be located in a sheltered, dry place, such as a gentle slope on the sunny side of a barn.

The essentials for a hotbed are bottom heat, protection on all sides, and a sash of glass as cover. The heat is usually supplied by the fermentation of horse manure. The manure should be taken fresh, with about half as much of the straw or litter used as bedding as there is of manure. It is piled in a long heap about 4 feet high with the top level. If kept under cover, the manure will be more effective. The pile should be rather narrow for convenience in handling. If fermentation does not start readily, wetting with hot water will start it. The heap should be turned several times at intervals to insure uniform fermentation. In turning any lumps should be broken up and the warmer portions mixed through the heap. When the fermentation has well filled the entire heap, the hotbed may be made.

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[1] Yearbook, 1896, p. 305.

The pit for the hotbed is 1 to 3 feet deep. It may well be built for permanent use, and then brick walls are economical. Board walls are as good as long as they last. Good drainage is essential. The pit should be filled with litter during the winter to prevent freezing on its inner surface. This is especially true if plants are to be started in winter. The litter is thrown out when the time comes to make the bed. Then an inch or two of coarse stuff is put at the bottom, and upon this 18 inches to 3 feet of manure is placed. Next comes a layer of leaf mold and on top 4 or 5 inches of fine garden loam.

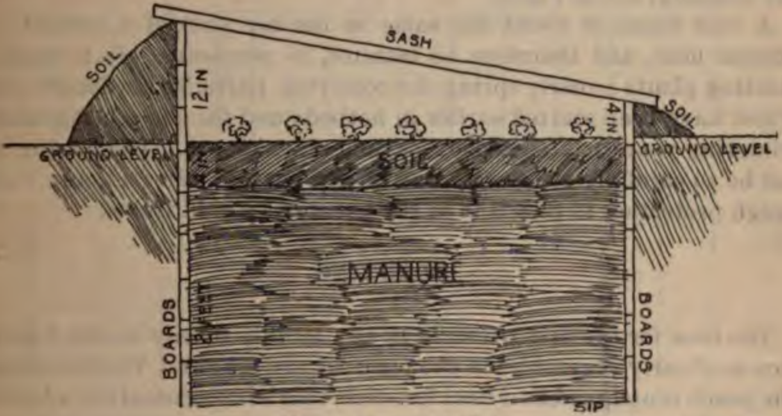

FIG. 4.—Section of hotbed.

The manure should be trodden down in layers about 6 inches thick. If it is loose and fluffy after being trodden, there is too much straw in it; if it packs soggy and solid under the foot, there is too little straw. It should feel springy when trodden, but should not swell up quickly in a loose mass when released from pressure. A hotbed with 2 feet of manure in it may be expected to be good for six weeks.

Mr. William Saunders, for thirty-four years Horticulturist of this Department, prefers that the pit beneath the hotbed should be only a foot deep, leaving most of the manure above ground. Otherwise the heat is drawn off by the cold earth. It is the practice of some gardeners to make the bed entirely above ground. In that case the frame should be at every point about a foot inside the edge of the manure heap. This form gives an opportunity to add to the sides of the bed when the heat begins to decline.

The frame in either case faces south, and is 6 to 8 inches higher at the back than in front. It is covered with a sash slanting to shed the rain, and so placed that it may be raised or pushed aside to allow ventilation. This sash can usually be bought ready-made 3½ by 6 feet in size, and this fixes the size of one section of hotbed.

Experience enables the farmer to judge by the warmth to his hand when it is time to plant seed in the hotbed. If a thermometer is used, 90° is the temperature for planting tomatoes and other plants requiring much warmth, while 70° to 80° will suffice for others. Not all kinds of seed are to be sown in the hotbed at the same time. Attention must be paid to the time at which transplanting must be done. When the plants are ready to go to the cold frame it is a loss to leave them in the hotbed. But if it is still too cold for them out doors a loss will occur by removing them. Care must be taken not to allow the bed to become too hot when the sun comes out suddenly, and to give plenty of fresh air. Whenever the temperature is above freezing the sash may be removed part way. Water should be given as needed, but in the morning, not at night.

A cold frame is about the same as the top part of a hotbed. No bottom heat, and therefore no manure, is necessary. It is used for starting plants in early spring, for receiving partially hardened plants which have been started earlier in hotbeds and forcing houses, and for wintering young cabbages, lettuce, and other plants. The boxing need not be so carefully constructed as in the hotbed. In fact, any sort of rough protection to plants is in the nature of a cold frame.

## PLANTING.

The time for the first planting in any locality is only known by experience, if early vegetables in the open air are sought. The blooming of the peach is assigned as a time for seeds that will germinate in a cold soil and resist a slight frost. Among these are peas, spinach, and onion. When the oak leaf breaks from its bud is suggested for beets, turnips, corn, and tomato. Seeds that thrive only in warmer soil, as beans, cucumber, canteloupe, watermelon, squash, and okra, may be planted when the blackberry is in blossom. The planting must be made, of course, with due consideration of the date when the vegetable is expected to be ready for use, and if a continuous supply is desired through the season several plantings at different dates must be made. These are known as successional plantings. An estimate of the number of days from planting to use is given in directions for culture, page 15 and following.

The garden should be planted, when it is practicable, so as to allow cultivation by plowing. Where this can not well be done, wheel tools will be found a great advantage. Usually there must be some hand weeding, but it should be reduced to a minimum. For this reason the rows should be long and continuous. If enough of one kind of vegetable to make a long row is not wanted, several kinds may be put in the me row. The accompanying illustration (fig. 5) from Bailey's Hor-ulturist's Rule Book furnishes a plan for such planting as is sug-

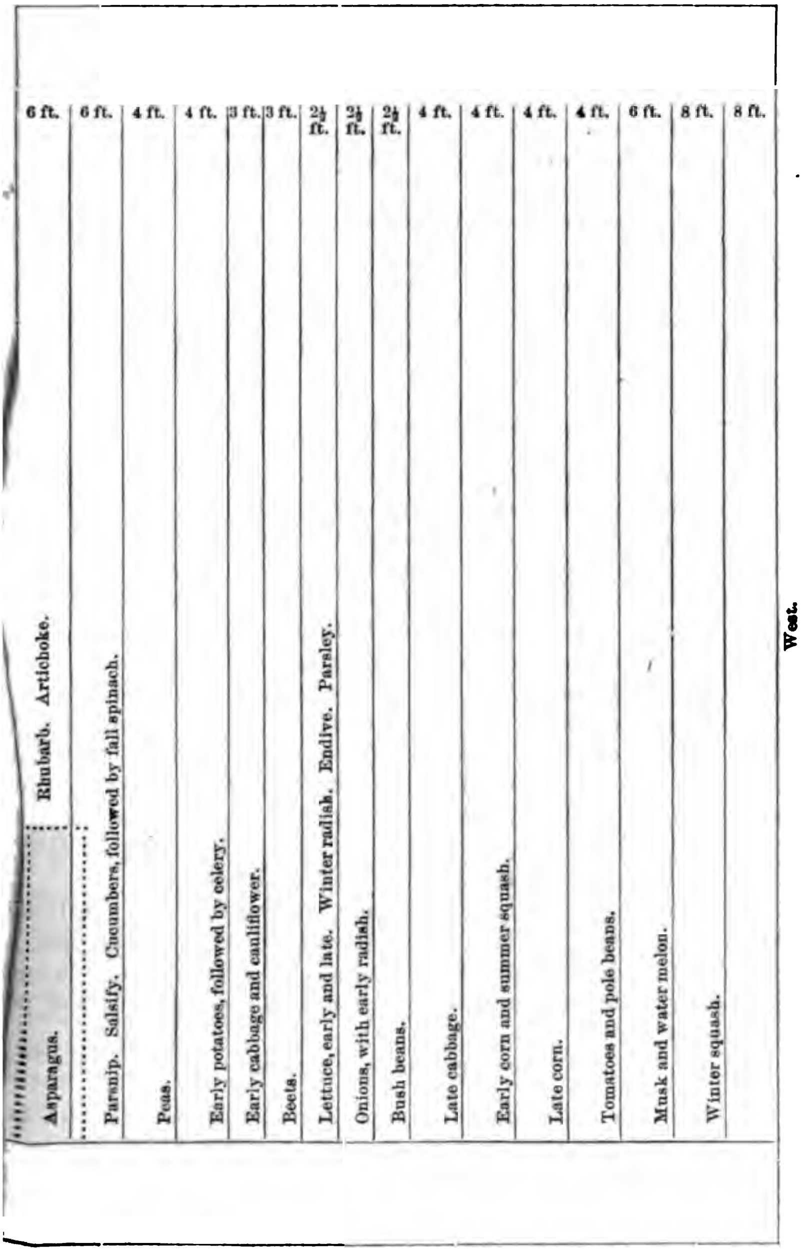
6 ft.
Asparagus.
Rhubarb. Artichoke.
6 ft.
Parsnip. Salsify. Cucumbers, followed by fall spinach.
4 ft.
Peas.
4 ft.
Early potatoes, followed by celery.
3 ft.
Early cabbage and cauliflower.
3 ft.
Beets.
2½ ft.
Lettuce, early and late. Winter radish. Endive. Parsley.
2½ ft.
Onions, with early radish.
2½ ft.
Bush beans.
4 ft.
Late cabbage.
4 ft.
Early corn and summer squash.
4 ft.
Late corn.
4 ft.
Tomatoes and pole beans.
6 ft.
Musk and water melon.
8 ft.
Winter squash.
8 ft.
West.

FIG. 5.—Tracy's plan for kitchen garden.

ted. The rows are about 100 feet long. It will be convenient to e two narrow footpaths across the garden, dividing it into thirds, but these need not break the rows so that they can not be plowed or wise cultivated throughout their whole length without turning. T direction of the rows east and west is preferred by some.

### MARKING THE ROWS.

Various devices have been suggested for marking the rows for pl ing. A roller, which will serve at the same time as a marker, of a smooth, hard-wood log with heavy rope secured firmly ab distances corresponding to the intervals desired between the When plants or seeds are to be dropped at intervals, the places ma marked by knots in the rope. A roller may be made of a sewer knocking off the collar and filling the hollow with cement. Wh marker is not available, the row may be opened with a hoe. A should be employed to keep the rows straight and parallel to other; the better results will more than repay the extra trouble.

### CONDITION OF THE SOIL.

The soil should be moist when the seed is put in it. Many pe prefer that the planting should be done just before a rain; but in practice care must be taken against the baking of the soil over seed. It is usual to firm the earth above the seed by patting it lig with a hoe or walking over it placing one foot close after the This is to make sure that the soil is brought close against the Small, weak seeds must not be put in ground that bakes or is thoroughly prepared. It is well to sow some large seed of vig growth, such as radish or turnip, with celery and other small seeds. The added seed come up, breaking the crust, so as to let the weaker plants. Also they show where the row is, and this ma way for cultivation before the crop is up. Of course the radishes or nips must be pulled up as soon as the other plants appear. Celery other seeds that germinate slowly should be shaded.

Most seeds must be sown much more thickly than the plants ca profitably grown. If they come up well thinning is necessary, this should be done, as a rule, as soon as the first true leaves app In thinning care must be observed not to loosen the roots of pl that are left.

### DEPTH OF PLANTING.

The depth of cover depends upon the size of the seed, its of germination and early growth, the soil, and the season of plant Planting too deep is a frequent cause of failure to come up. Warm air, and moisture are necessary to germination. In the spring ture is usually abundant, while warmth is lacking. The soil is war near the surface. Accordingly the cover should be shallower tha summer, when warmth is abundant and moisture is lacking in the face soil. A clay soil admits air and warmth less easily than do sandy soil, and therefore allows less covering. Small, weak seeds should have less cover than large, vigorous seeds. Some kinds, as celery, must be merely pressed into the soil, and have a little sand or dust scattered over them.

Soaking the seed may prove injurious if continued too long, but there is advantage in the case of kinds that are slow to germinate, such as beet, carrot, and parsnip. Also thick skins, as of beans, are loosened by soaking, and the plants will come up probably a day or two earlier.

### TRANSPLANTING.

The time for transplanting from the hotbed or cold frame is usually soon after the formation of the first true leaves. The weather should be cloudy or rainy and the ground into which the young plants are to be put should be in the best of condition. The earth should be pressed closely about the roots of the plants in their new place, and if the sun comes upon them they should be shaded with large leaves, shingles, or stones. Small plants may be shaded with screens folded from paper and held in place by stones. If the leaves of the young plants are clipped off about half-way back from the point, the evaporation from them will be lessened that much and the roots will have an opportunity to establish connection with the soil and secure ample moisture before the full demand from the leaves is renewed. By this the plants' chances for living will be materially increased.

Some plants bear transplanting much better than others, but any plant can be removed from place to place at will if the mass of earth about the roots be preserved nearly unbroken in the process.

### ROTATION.

Of course the same vegetable should not be grown year after year in the same part of the garden. A proper rotation is comparatively as important in the garden as in the field. Investigation has shown that beans, peas, and other legumes collect nitrogen from the air and leave it in the soil. It follows that deficiency of nitrogen may be supplied by growing leguminous crops, and they may be followed by other vegetables that especially need nitrogen.

Among suggestions for rotation are the following: Lettuce may be succeeded by beans and tomatoes; beans by turnips, radishes, or celery; peas by cabbage or celery; beets by spinach, lettuce, or okra; onions by turnips, peas, beans; cabbage, okra, celery, squash, melons, or cucumbers by beans or peas; corn by melons, cucumbers, squash, beans, or peas.

### CULTIVATION.

The chief purposes of cultivation are to keep down the weeds and to maintain in the soil a supply of air and moisture favorable to plant growth.

The moisture in the soil about a vigorous plant is rapidly carri
by evaporation from the leaves. As long as the ground con
ordinary water supply for several feet below the surface a stea
of moisture goes upward through the minute spaces between
grains. The upper layers of soil are kept from becoming dry
flow. But when the rainfall is scant the moisture in the lower
becomes exhausted and the plant curls up and dwindles. A
prevails. The gardener must provide against the occurrence
condition. It is not enough to remedy it; he must prevent it.
the most efficient means is a mulch, which is most convenientl
of the surface soil.

### TIME FOR THE SOIL MULCH.

Usually as soon as a rain is over the atmosphere is free of m
and evaporation from the soil sets in. The water that has just
in comes up through the little pores between the soil grains and
off from the surface of the soil into the air. The gardener's a
the mulch is to save this moisture and send it through his pla
the little pipes or tubes formed by the pores of the soil are brok
flow through them is checked and evaporation from the ground
lessened. It is only necessary then in order to save the moist
the plants to break up the surface of the soil with a rake
implement.

It is a serious mistake to suppose that so long as the surface
moist the soil below is well supplied with water. A damp surf
mean only that moisture is rapidly evaporating into the air.
as the surface becomes solid it should be stirred with a rake
As a rain or even a shower compacts the soil at the surface, the c
notion that it renders raking or shallow plowing less necessary
cisely contrary to the fact. It is then especially that the surface
be broken. The same is true after irrigation. The raking or
should be done as soon as the soil will not cake when squeezed
hand.

### IRRIGATION.

But frequently dry weather continues so long that it is imposs
preserve sufficient moisture by tillage or any sort of mulching.
becomes necessary to water the garden. Where there is con
with city water works the supply is ample and easily reached. In
locations various forms of cisterns and reservoirs are employed.
it is possible the reservoir should be a few feet above the level,
any part of the garden can be reached with a hose or a V-shaped
The proper application of water appears to be very simple, bu
fact quite difficult.

It is not unusual for an inexperienced person to sprinkle the
every day or two and think he is relieving the drought. The
such treatment is likely to be harmful, especially if the sprink

wed to leave a crust about the plants. In watering, the earth should horoughly wet, so that the moisture will get to the lower and outer ts of the plants. In order to check evaporation after sprinkling, the face should be broken as soon as dry enough to work. The watering uld be repeated when it is evident, upon careful watching, that more sture is necessary. It must be remembered that the small, active ts, which take up moisture and plant food, are most numerous at the remities of the large roots and at a distance from the stem. The er must be so given as to reach these small roots.

he best time for watering is generally thought to be at evening, but air says: "In the spring, in the middle of the day, because the ning and evening are too cool; in the summer, at evening because days are so hot that a great part of the water given during the day ld be evaporated immediately; in autumn, in the morning, because nights are cold."

r. Saunders says: "Water at any time when the plants need it, water thoroughly. When I am told that watering in the sunshine on will burn up my plants, I answer that the plants will certainly up if I do not water them."

## KILLING THE WEEDS.

eeds will be most troublesome when rain is plentiful. The plow hoe ought to be depended upon mainly. Hand weeding is neces- in some cases, but is always slow and tiresome. Various forms of ivators and wheel hoes are in use and have many advantages over ordinary field implements. Also, there are several forms of hand made to cut just below the surface and kill the weeds more effec- ly and rapidly than the ordinary hoes will do.

everal kinds of grasses are the hardest to deal with when once they set in the ground. The worst of these are witch grass, or couch s, and Johnson grass. Sometimes very troublesome but less rtant are crab grass, Nimble Will, and Bermuda grass. The thing with these is to see that they are well killed out before the gar- s planted and not to allow them a start afterwards.

## INSECTICIDES.

rious forms of insecticides are used to kill cabbage worms, potato , and the like. Farmers' Bulletin No. 19 gives directions as to reparation of many of these. Hand picking of worms and brush- ugs off the plants into baskets are primitive means of protection, ometimes prove the most practicable and most effective. A flock rkeys often proves to be of great assistance against insects.

## SPECIFIC DIRECTIONS FOR SEVERAL VEGETABLES.

**tichoke.**—The Jerusalem artichoke (fig. 6) in a deep, favorable loam, prepared, will produce at the rate of 300 to 600 bushels to the acre.

Two or three tubers, if small, are planted in a hill. The hills ar feet apart each way. Cultivation is necessary if good results a desired, but the plant will produce without any care whatever. T tubers are ready for use early in October and may be dug at any ti when the ground is not frozen an late in March. Freezing does n affect them and they come to th table fresh from the earth in the ear spring when other vegetables ar likely to be stale and musty. Th are boiled or steamed till soft an served with cream sauce; they ar also used as salads or pickles. Th have about the same food value a potatoes. A pint of tubers, cut t eyes as potatoes are, will plant 25 t 30 hills.

**Asparagus.**—This vegetable is on of the earliest to be ready for us A fertile soil is best, but any go ground thoroughly prepared do well. Fine sandy soil makes th plants gritty. Sow early, in rows feet apart; cover rather lightly

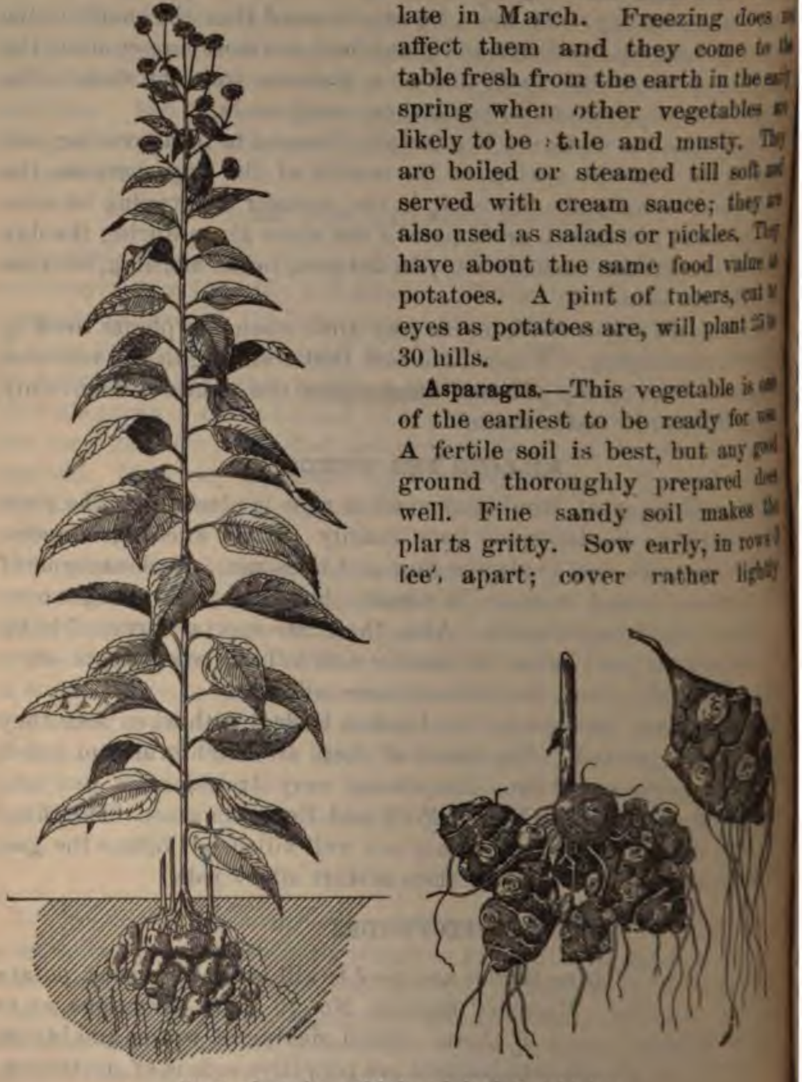

FIG. 6.—Jerusalem artichoke, whole plant and tubers.

Thin when 3 or 4 inches high to 1 foot in the row if the soil is stron farther apart on a sandy soil. Cultivate carefully, and supply a go dressing of well-rotted manure each spring. The plant should gro vigorously. It will be ready for use in the third year, and should b cut until late in June. It should then be well worked and left to gro to gather strength for the next year's crop of shoots. When the tops begin to die they should be cut and burned. The asparagus on the market is usually white, except a small tip, and the white portion is stringy and inedible. This is the result of deep setting and cutting. If the seed is planted as here directed and the shoots cut a little below the surface when 2 to 3 inches high, a dish considered by many persons to be more satisfactory will be obtained. Two and one-half ounces of seed will sow 100 feet of row. A year may be gained by purchasing the young plants a year old and setting them out 4 inches deep. For details on asparagus growing see Farmers' Bulletin No. 61.

**Beans.**—A light, loose soil, fertile and well prepared, will give the best results for snap beans, and the crop will be the earlier for a considerable per cent of sand; but a fair return may be expected from almost any soil with ordinary care. Sow as early as frost will permit in drills 3½ feet apart and cover 1 to 2 inches deep. The plants should stand 5 to 7 inches apart in the row. The tillage should be with a horse cultivator. If the space is small the rows may be 8 to 12 inches apart. The plants should not then be quite so close in the row, the supply of fertilizer and water a little more generous, and a wheel hoe should be used in cultivation.

Beans will be ready for the table in six to eight weeks from planting. If wanted very early they can be handled successfully from the hotbed. All green pods should be picked as soon as seed begin to form. By a judicious selection of kinds a succession can be secured without delaying the planting. One quart sows 100 feet of drill.

Lima beans are planted in drills 3 feet apart and allowed to stand 20 inches apart in the row. The beans should be placed with the eye down and covered 2 inches deep. Pole beans, both snap and lima, must be planted later than the dwarf varieties, as they are more easily injured by frost. Three or four plants should be left in each hill. One pint sows 100 hills. Ready for use, lima in 90 days, pole in 110 days.

**Beets.**—Loose, rich soil with considerable sand is desirable, but beets will grow well in any except a hard, heavy clay. The seed should be planted about an inch deep in drills 3½ feet apart. The sowing may be quite early, as the plants will stand a light frost. When growth has fairly begun thin to 6 or 8 inches in the row. The plants removed may be used as greens. Turnip or globe-shaped are liked best for summer use; the long varieties for winter keeping. Leaf blight is occasionally troublesome in beets and may be met by spraying with Bordeaux mixture.[1]

Winter beets are sown in July and August, and after frost are taken up, the tops cut off, and the roots stored in the cellar. One ounce of seed will sow 60 to 70 feet of drill. Early varieties may be used in 50 to 60 days; the roots will be mature in 150 days.

**Cabbage.**—The best soil is a deep, rich loam, well worked. Positions shaded during part of the day are to be avoided, for cabbages require abundant light and warmth. A liberal amount of stable manure or other proper fertilizer will make good returns.

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[1] See Farmers' Bulletin 19. Some Important Insect

The young plants should be started early in a hotbed and transplanted. Usually they must be kept for a time in the cold frame before being finally set in hills 3 feet apart. It is best to wait for a rain before setting out, but shallow drills may be made and soaked with water over night. A light mulch should be applied to the plants when set. In dry, hot weather water should be given liberally and the plants shaded carefully with boards or leaves.

Cabbages have several enemies, which will destroy the crop if left alone. Among these are root maggots, against which slips of tarred paper have been used successfully; cabbage worms, which may be destroyed with pyrethrum or kerosene emulsion, and club root, for which there is no known remedy.

One ounce of seed will produce 1,500 to 3,000 plants. Ready for use in 100 to 160 days.

**Carrots.**—Sow early in loose, rich soil in rows 3 feet apart for horse cultivator or 1 foot for the hoe. The seed is small and slow to start. It should be covered lightly and pressed down firmly. If radish seed be sown in the same row they will break the surface and mark the rows so that relief may be given if the ground should bake. Thin to 4 inches apart in the row. Carrots are considered best when young and tender, and successive sowings will be necessary to supply them in that condition. One ounce will plant 150 feet of row. Carrots may be used in 70 to 120 days, varying with variety, management, etc.

**Cauliflower.**—This vegetable deserves more general cultivation in the farm garden. It can be raised with about the same soil, planting, and care as cabbage, but the supply of moisture must be maintained more carefully. The plants do not stand very hot weather. When the plants begin to head the loose leaves should be bent over to whiten the center. One ounce of seed will give 1,000 to 2,000 plants.

**Celery.**—Unusual care is necessary to grow celery, but it seldom fails to respond to proper treatment. Light, rich, and very fine soil is needed to plant the seed in, and a rich, peaty loam, "a sandy muck or mold, or any loam that is abundantly supplied with humus", is right for growing the celery to maturity.

Young plants may be bought, but it will frequently prove cheaper to grow them from the seed and they will then be stronger and thriftier. The seed should be sown early in the house or in a good hotbed. They require a very little covering of fine earth and some growers merely press them into the soil. A small box will give room for starting an abundance of plants. When the second leaves appear they should be transplanted 1½ to 2 inches apart in large boxes, and as they begin to grow should be hardened by exposure to the open air and sun in the warm part of the day. When settled warm weather has come, May or

One to two ounces of seed will plant 100 hills. Ready for us
75 days.

**Ground cherry.**—This plant (fig. 7), also known as strawberry
cherry, grows wild in the cornfields of the Mississippi Valley.
is used for preserves for the table. A good soil well worked i
the quantity and quality of its production. It may be plante
drills 3 feet apart, with 12 to 18 inches between the plants in
It is recommended as very productive
keeping through the winter in the husk.

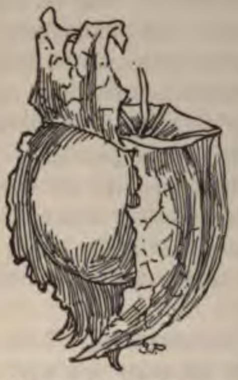
FIG. 7.—Ground Cherry.

**Lettuce.**—This plant is the most genera
in this country for salads. A warm m
is required, with plenty of water and t
weeding. Sow as soon as danger of se
is past. The seeds are very small an
mixed with sand for sowing. They s
covered very lightly. In the Southern
is usual to sow the seed broadcast and
drawing the fingers lightly through th
to rake in with a light branch of a t
ordinary rake will cover too deeply. C
the cabbage lettuces, form heads natu
other, the Cos lettuces, do not head, bu
blanched by tying up the leaves. Lettuce may be used in 3 t
from planting. One-quarter of an ounce of seed will sow
of drill.

**Martynia** (fig. 8).—A rich, warm soil is needed. Plant whe
gone for the year in hills 3 feet apart each way. The seed
come up. One good plant to the hill is enough. The seed
be ready for pickling in 60 to 80 days and are put up in the
as cucumbers. Half an ounce of seed will plant 100 hills.

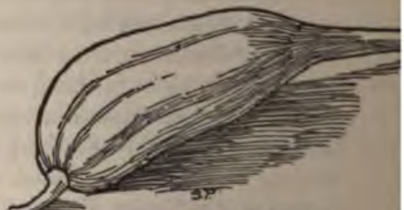
FIG. 8.—Martynia.

**Melons.**—Both muskmelons (cantaloupes) and watermelons need a warm, rich soil; but care must be observed not to grow the vines at the expense of fruit by improper use of fertilizing materials. Melons grow readily in a fertile sa
The management is about the same as for the cucumber,
light, heat, and air are needed and not so much moisture.
may be pinched back if they tend to run excessively. M
need 2 ounces of seed to the 100 hills; watermelon, 4 ounces
melons ripen in about 100 days from sowing the seed, water
120 to 140 days.

**Okra.**—A deep, rich soil well prepared is to be desired for okra, but it makes a thrifty growth and will do well with very little care after it has a good start, unless the season is very wet and cool. The seed does not come up with much certainty, and two or three plantings may be necessary. Seed should usually be procured fresh from a dealer every year, but with intelligent handling it may be saved from the pod. Okra should be planted as soon as frost is gone, in drills 2½ to 3 feet apart and covered an inch deep. Thin to 12 or 18 inches as soon as the plants begin to grow well.

The pods are cut 3 to 5 days after the flowers fall, and are usually boiled alone or in soup with other vegetables. One and a half ounces of seed will plant 100 hills. Use of the pods may begin in 90 to 100 days from planting.

**Onions.**—A rich, deep, friable loam is the best soil. Sow early in shallow drills 1 to 3 feet apart, and cover with half an inch of well pulverized soil. Thin to 4 inches in the row. Keep down the weeds industriously. This will usually require working every ten days. Instead of sowing seed, the sets may be put out 4 to 6 inches apart in rows a foot apart. The ground does not then need to be so finely pulverized before planting. If the sets are put out in October they will furnish slender white stems for the table about two weeks from the beginning of growth in the spring. Onions well ripened keep well through the winter in a dry, cool place. One-third ounce of seed or 1 quart of sets go to 100 feet of row. Farmers' Bulletin No. 39 furnishes full details on onion culture. Ready for use in 100 to 110 days; ripe in 160 days, according to variety.

**Parsley.**—This is a biennial. Deep rich soil made very fine and mellow is best. Sow early in the spring in drills half an inch deep and a foot apart. Thin to 6 inches in the row, when the second pair of leaves appear. If wanted in early spring parsley may be sowed in September in a moderately fertile soil. During the cold weather the plants should be covered nearly to the top with leaves, held in place by brush. One-fourth of an ounce of seed will sow 100 feet of drill.

**Parsnips.**—This vegetable is grown precisely as the carrot (p. 18). It may be left in the ground all winter and dug as wanted. It is considered sweeter and better when managed in that way. One-fourth of an ounce of seed will sow 100 feet of drill. The roots are ready for use in 140 days from planting.

**Peas.**—Frost is not so fatal to peas as to beans, and the sowing may therefore be earlier. The soil, planting, and cultivation are practically the same as for beans (p. 17), but peas require a better soil and more attention. Some of the best peas grow tall and require sticks or wire to hold them off the ground. The half dwarf kind may be planted in close rows so that they will support each other. The seed does not come up with quite so much certainty as beans and the [illegible] to suffer more by accidents and disease. Mildew is enemy, and is treated with Bordeaux mixture. (Footnote Weevil in the seed may be killed by soaking for an hour in a s of an ounce of copper carbonate and a little less than a pint of am to 1½ gallons of water. If peas are wanted for several weeks, suc sowings must be made or varieties judiciously chosen.

Two distinct kinds of peas are known, smooth seeded and wr seeded. The latter are earlier and last longer; the former som have edible pods and are known as sugar peas. One pint of se plant 100 feet of drill. Ready for use in 50 to 90 days, accordi variety.

**Potatoes.**—A rich, sandy loam is the most favorable soil. It s be thoroughly loosened so that the tubers may grow freely. as soon as frosts cease, about 3 inches deep, 12 to 18 inches ap rows 3 feet apart. The tubers are cut for planting so as to lea or two eyes to each piece. Level cultivation is preferred. The must be kept down, and when the potato bugs appear they m killed promptly by a free use of Paris green or by brushing off b A second planting, covered deeper, about May day will give p for use in August, and a still later planting will furnish the fa In digging and storing potatoes should not be much exposed t A peck of potatoes will plant 300 feet of row. For additional mation regarding potatoes see Farmers' Bulletin, No. 35. Potat ready for use in 85 to 135 days.

**Radishes.**—Among the first usually sown are radishes. They little space and can be grown indoors. A loose, rich, deep soil, if sandy, is required. The radish should grow very rapidly eaten while still very young. The drills are made 12 to 14 apart and the plants 3 inches in the drill. The seed should be c about an inch deep. It comes up well, but should be planted and thinned promptly. Radishes are frequently sown broadca raked in lightly. Grubs sometimes destroy the roots. The only is to plant in soil where the grubs have not found lodgment. Fr sowings will be made by those who enjoy fresh, crisp radishe ounce of seed will sow 100 feet of drill. Ready for use in 20 to according to kind.

**Rhubarb.**—The soil should be deeply worked and rich, but th will grow with ordinary care upon any good ground. An open p sheltered from east winds, is desirable. Bone meal and barnyard are recommended as fertilizers. Rhubarb may be grown by the seed in the spring, but it is better to use the divided roots plants. They should be set 2 to 3 feet apart and may occupy an wise unused corner. Once set, it will produce for several yea very little attention. Use begins in the second season and discontinued in the summer in time to allow the plants to rec for the next year. An ounce of seed will sow 125 feet of drill.

**Salsify.**—The planting and cultivation are the same as for the (p. 18), except that a little more space between the plants in t e an advantage. Salsify may be left out all winter if freezing is ery severe, but it is considered better to pull and store.

e ounce of seed will sow 100 feet of drill. Ready for use in 130 to ays.

**nach.**—For early use sow in a sheltered place in a dry, well pre- d, fertile soil. Later the plants seem to need moister ground. If in the fall, spinach can usually be wintered under a mulch, which ld be removed early in the spring. The drills should be a foot and the seed covered about an inch deep. Thin to 6 inches apart, nally, as the plants grow, to 12 inches in the row. Gather two or of the largest leaves as wanted from each plant as soon as they rge enough. Cut the heads when flower stems appear. New Zea- spinach is a new variety quite different from the common. The s should stand 3 feet apart. Perpetual spinach is sown in rows a part in very rich soil and thinned so as to give plenty of room. an ounce of seed is right for 100 feet of drill of the ordinary kind; nts of the New Zealand is enough for a family. Ready for use in 35 days; New Zealand, 40 to 55 days.

**ash.**—A warm, light, rich soil, deeply worked, is best. Plenty of e manure will be repaid by increased yield. Plant summer varie- in slightly elevated hills, 4 feet apart each way, as soon as the nd is warm. Place the seed upright, with the eye down, and cover 3 inches deep. Late varieties should be planted in hills 6 to 8 feet way, leaving four plants to a hill. Another way is to plant in 12 to 20 feet apart and thin to 6 feet between hills in the row. y beans or peas may be cultivated between the rows, to be cleared in July. Weeds must be kept down and moisture held by culti- n. The hand hoe must be used after the vines begin to run. from the home garden is likely to be crossed with cucumbers or ns and the product unsatisfactory. One ounce of seed for summer wo ounces for winter will plant 25 hills. The summer squash may ed in 50 days; winter squash will be ripe in 115 to 125 days.

**eet corn.**—This crop requires much room and a rich soil, broken It does not demand the careful pulverizing and loosening of the nd before planting which is usual in garden culture but will better results for this and other generous treatment. Plant as as danger of frost is past in drills 3½ feet apart, dropping three or grains every 18 inches, or in hills 3½ feet each way. Cover 2 to 4 es deep. Keep the surface of the earth broken, so as to insure ty of moisture and kill the weeds. For the garden the early sweet eties are most useful. They will come to the table several weeks er than the large field kinds. Successional planting should be e, and about an eighth of an acre should give a constant supply of ting ears for an ordinary family. One-fourth to one-half pint will t 100 feet of drill. Corn should be ready for use in 55 to 85 days.

**eet potato.**—Warm, sandy, rather dry soil should be selected if able. Plants may be bought. If raised in the hotbed the old potatoes should be buried 2 or 3 inches deep in the bed two or three weeks before the plants are wanted. When frost is gone set the young plants in well-manured rows 5 feet apart and 12 to 18 inches in the row. Shallow cultivation is to be given, killing the weeds and keeping the soil loose. When the vines begin to run they must be laid aside befor plowing. In some localities the crop is much injured if the vines tak root in running, and this is prevented by moving them after other attention has ceased. Two to four plowings with the cultivator an one or two hoeings will be enough. They will be ready for use late i August, when a little more than half grown. They are taken from th hills as wanted without pulling up the vines. The potatoes are all du when frost kills the vines. Five hundred plants will set from 350 t 500 feet of row. Additional information is given in Farmers' Bulle No. 26.

**Tomato.**—A clayey soil is liked by some, sandy by others. Dee preparation and plenty of manure will make good tomatoes on almo any soil. Too much manure on a light soil may cause the plant to ru to vine. Sow the seed in the hotbeds about the end of March, and s the plants when 2 inches high 3 feet apart in rows 3½ feet apart. Th should not be set out till the temperature is likely to stay above 6 This will usually be when oak leaves are well out of the bud.

Thorough cultivation, loosening the soil and killing the weeds, necessary till the plants begin to spread and cover the ground. T soil should be drawn up to the plants in hills 2 or 3 inches high. So support, as a trellis, is necessary to keep the fruit off the ground.

The fruit will begin to ripen in August, and should be picked as f as ripe. The plant will usually continue bearing till frost, and if t full-sized green tomatoes are then placed under a cold frame or on t cellar floor they will usually ripen. One ounce of seed will prod 3,500 to 4,500 plants. Farmers' Bulletin No. 76, Tomato Growing, gi full details.

**Turnips.**—Rich finely pulverized soil is needed. A sandy or grav loam is preferred. The seed may be sown quite early, as the pla are not easily hurt by frost. Sow in drills 1 foot apart and half an i deep, or sow broadcast and rake in lightly. If there should be no r a thorough sprinkling will insure germination. The plants sho stand at least 3 inches apart. Repeated sowings are necessary fo satisfactory succession in summer. White varieties are preferred summer use.

For winter, sow late in July. A yellow kind is much liked. No tivation is required when sown broadcast. Turnips may be stored same as potatoes. The tops should be cut away. If covered with they will not wither, but may start to grow if the cellar is war will become pithy. Turnips mature in about two months. One of seed is enough for 200 feet of drill.

Issued February 14, 1908.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 104

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# NOTES ON FROST.

BY

E. B. GARRIOTT,
Professor of Meteorology, Weather Bureau.

Revised January, 1908

WASHINGTON:
GOVERNMENT PRINTING OFFICE
1908.

# LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of the Weather Bureau,
*Washington, D. C., January 25, 1908.*

Sir: I have the honor to recommend that the manuscript herewith be published as a revised edition of Farmers' Bulletin No. 104.

In compliance with directions contained in your letter of March 29, 1899, a paper on the subject of frost, prepared by Prof. E. B. Garriott, Weather Bureau, was submitted and published as Farmers' Bulletin No. 104. This bulletin furnished valuable information regarding methods of protection from frost. Methods advocated in previous publications were mainly the results of experiments conducted in California orchards. Bulletin No. 104 was designed to be of value in all sections of the country rather than in restricted districts.

As the California experiments quoted were perhaps the most thorough ever made in this country, a description of the methods employed and the results obtained is reprinted in brief in this paper, together with results of similar experiments made in the citrus-fruit and truck-growing districts of the Gulf States, where varying climatic conditions have been found to produce somewhat different results. Additional information personally acquired by the author during a visit to Florida in the winter of 1906–7, and certain climatic data, also form features of this paper in its revised form.

Your wishes that the subject be treated in a popular way and divested of all technicalities, and made applicable to all portions of the United States, have been complied with so far as the nature of the subject will permit.

Respectfully,

Willis L. Moore,
*Chief, Weather Bureau.*

Hon. James Wilson,
*Secretary of Agriculture.*

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# NOTES ON FROST.

## HOW FROST IS FORMED.

he atmosphere of the earth always contains more or less moisture an invisible form. When at a considerable elevation above the th this moisture, or aqueous vapor, is condensed, clouds are formed; en the process of condensation is more active and the temperature he air is above freezing, rain falls; and when the temperature of air is below freezing, snow is produced. When the moisture of air in immediate contact with the earth is condensed at tempera- es above freezing, dew is formed; when at temperatures below ezing, frost is deposited. Frost is, therefore, the moisture of the condensed at freezing temperatures upon plants and other objects r the surface of the earth.

n the process of frost formation the temperature of the air a few t above the earth is commonly several degrees above freezing. The faces upon which frost is deposited must, however, possess freezing peratures. The manner in which frost is deposited on plants and er objects is very similar to that in which the air moisture of om is frozen and deposited upon window glass, the temperature of ich has been reduced to freezing by the out-of-doors cold. In the e of the frost on the window glass the process is one that can read- be understood. Some explanation, however, is required of the mation of frost, which requires freezing temperature, when at es a temperature above freezing is registered a few feet above the faces upon which frost appears.

There are several processes by which the temperature of plants may reduced below the temperature of the air which surrounds them. e most important of these processes is radiation, by means of which t escapes from objects and passes into the surrounding air.

n the frost-forming process heat from the sun which is absorbed the earth and by plants during the day is lost by radiation at night. ring the day the earth both absorbs and reflects the heat received m the rays of the sun, and the lower stratum of air is warmed by reflected heat. During the night when no direct heat is received m the sun's rays the lower air stratum receives no reflected heat,

nd, at the same time, heat which has been absorbed by the earth is
adiated, or, in other words, it rises through the overlying air, though
ot necessarily and entirely as sensible heat; that is, heat perceptible
) the senses. In the frost-forming process there is another very im-
ortant factor in the production of cold; that is, the evaporation of
ıoisture from the earth and from plants. The nature and composi-
ion of frost require that the air in immediate contact with the sur-
aces upon which frost forms shall contain moisture. This is mois-
ure that has been stored in the earth in visible form, i. e., in the form
f water, and which has escaped from the earth, not as visible mois-
ure, but by the process of evaporation and in the form of aqueous
apor. Some part of the heat stored by the earth during the day is,
herefore, lost in evaporating the moisture contained in plants and in
he earth. The heat utilized in this process is retained in the air, not
s sensible, but as latent heat. Heat is rendered latent, in the same
ıanner, when it is used to boil away water, and it again becomes sensi-
le or liberated heat when the water vapor produced by boiling, which
s a rapid process of evaporation, is again condensed into water. It
ppears, therefore, that while the temperature of surfaces upon which
rost forms, and of the air in immediate contact with them, is low-
red by the evaporation of moisture from the surfaces; the influence
f the process does not extend to air a few feet above the ground.

Another method by which plants lose their heat is by convection, by
ıeans of which they are chilled by contact with colder air. This
rocess, while important in the presence of freezing-air temperatures,
an scarcely be considered a factor in the formation of frost proper,
vhich is usually accomplished when temperature observations show
he air to be above freezing.

Another element in the formation of frost is found in the fact that when crops are maturing. In the first instance vegetation is threatened by the frosts of early spring, and in the latter by the frosts of autumn.

Considering the several agricultural sections in greater detail we find that damaging frost is likely to occur in the north half of the Florida peninsula and in the region immediately bordering the coast of the Gulf of Mexico, and in the Pacific Coast States from the latter part of October until the early part of April, and in the North Pacific Coast States as early as the middle of October and as late as the last week of April. From December until early in March the frost limit and even the line of freezing temperature may, at long intervals, be extended southward over central and southern Florida. The period of damaging frosts in the interior of the South Atlantic and Gulf States extends from November to April. From October to April the region in which agricultural products are subject to damage by frost is extended to the southern lake region, over the Upper Mississippi and Lower Missouri valleys, Kansas, and Nebraska, and from September to May frost visitations are usually confined to the extreme Upper Mississippi, Upper Missouri, and Red River of the North valleys, and the Rocky Mountain and plateau regions from central New Mexico and the Texas Panhandle northward.

The occurrence of summer frosts in mountain regions and in extreme northern districts of the country is common. The following are notable instances of summer frosts in agricultural districts:

August 22 to 24, 1890, a frost-bearing cool wave advanced from the Dakotas over the lake region and the interior, or mountain districts, of the middle Atlantic States.

August 28 to 31, 1892, a cool wave advanced from the Rocky Mountain and plateau regions, with frost from New Mexico to the Dakotas, Iowa, Minnesota, northern Wisconsin, and northern Michigan.

August 8, 1904, frost damaged vegetation in low-lying lands in the States of the upper lake region.

Bulletin P, of the Weather Bureau, gives a chronological statement of the more important cold periods that have been experienced in the United States, and contains charts that present conditions that have preceded and attended the principal cold waves and frosts of the last fifteen years.

## WHEN TO EXPECT FROST.

As the conditions which produce damaging frost are subject to modifications which are as numerous as the kinds of crops raised, and as varied as local topography, local climate, and local soil conditions in the various sections of the United States, the writer in attempting to treat briefly a subject which is so diversified in its as
fronted with many difficulties. Suffice it to say that with

pheric conditions favorable for its occurrence frost may, as a rule, be expected when temperature, as reported by stations of the Weather Bureau, falls to a point 8° to 10° above the freezing point. As previously stated, the surfaces upon which frost is deposited must possess freezing temperature, although the temperature of the air a few feet above the surfaces may be several degrees above freezing; and it is the temperature of the air, in some instances many feet above the ground, that is given by the Weather Bureau observations. Another atmospheric condition favorable for the occurrence of frost is a clear, cloudless, and comparatively calm night. The presence of clouds retards radiation or loss of heat from plants; the clouds act as a screen in preventing the heat collected from the sun's rays during the day from escaping into the upper air. When clouds are not present and a withdrawal of the sun's rays causes a rapid cooling of the air at moderate elevations, the warmer air which collects near the surface of the earth during the day rises, and the cooler upper air, owing to its greater density or weight, settles to the earth. It will be noted that clouds not only prevent the escape of the warm air in immediate contact with the earth, but also blanket, as it were, the upper part of the lower air stratum. Calm or comparatively still air is a condition which favors the formation of frost. On windy nights the air is disturbed and is not permitted to arrange itself in layers according to its density, with the densest and coldest air near the surface of the earth; it is kept mixed up by the wind.

A very interesting fact, which illustrates the manner in which cold air settles by its greater weight to the surface of the earth and allows the warmer air to assume higher levels, causing frost in low grounds and granting to the higher grounds a comparative immunity from frost, is set forth in the following article, by Prof. Cleveland Abbe, in the Monthly Weather Review for December, 1893, entitled Thermal Belts, Frostless Belts, or Verdant Zones:

> These are local names given to certain regions on mountain sides within which nocturnal frost rarely or never occurs in the springtime, although freezing temperatures occur in the winter time, consequently tender vegetation flourishes with remarkable vigor in these regions. The following are the only references to thermal belts in the United States at present known to the editor, but as such regions are specially important to the horticulturist and agriculturist it is hoped that the correspondents of the Weather Bureau will bring these thermal belts to notice wherever they occur in order that their meteorological peculiarities may be better understood.
>
> In the Agricultural Report of the Patent Office for 1861 Mr. Silas McDowell, of Franklin, Macon County, N. C., describes the verdant zone in that county in the valley of the Little Tennessee River. It occupies the region between 300 and 700 feet above the valley of the river, which latter is about 2,000 feet above sea level. On tracing this zone up among the smaller tributaries of the Tennessee River he found that in the higher valleys, where the bottom land *is about* 3,900 feet above sea level, the verdant zone lies between 4,000 and

4,100 feet. Within this zone frost never injures the vegetation, and the most tender grapes never fail to produce abundant crops.

Prof. J. W. Chickering, jr., in the bulletin of the Philosophical Society of Washington, March, 1883, and in the American Meteorological Journal, vol. 1, describes the following thermal belt: "In Polk County, N. C., along the eastern slope of the Tryon Mountain range, in latitude north 35, the thermal belt begins at the base of the mountain, at an elevation of 1,200 feet above the sea, and extends up 2,200 feet, being most perfect at about 1,500 feet. It is about 8 miles long, and is distinguished by magnificent flora, such as would be characteristic of a point 3 degrees south of the actual latitude."

Prof. John Leconte, of Berkeley, Cal., in Science, vol. 1, p. 278, states that at Flat Rock, near Hendersonville, Henderson County, N. C., on the flank of the mountain spur adjacent to the valleys of the Blue Ridge, he also observed a frostless zone. The valley is about 2,200 feet above sea level, and the thermal belt is 200 to 300 feet above the valley.

Mr. J. W. Pike, of Vineland, N. J., states that among the mountains of California he has discovered that during the night the cold is much greater in the valleys than on the terraces several hundred feet above, due to the settling of the cold air, so that a thermal belt is formed at that height separating the frosty valleys from the colder highlands.

In the Tennessee Journal of Meteorology for January, 1894, published by the State weather service, the author describes a thermal belt between Los Angeles and the Pacific coast. It traverses the foothills of the Cahuenga range, and has an elevation of between 200 and 400 feet and a breadth of about 3 miles. It occupies the midway region of the range.

In the American Meteorological Journal, vol. 1, Mr. S. Alexander describes a thermal belt in which the peach tree flourishes in the southeastern portion of Michigan. He shows that the cold island discovered by Winchell in that region is really the bottom of a topographical depression into which the cold air settles. It is a long valley surrounded by a belt of elevated country from 50 to 600 feet above lakes Michigan and Huron. The valley and the isotherms trend northeast and southwest from Huron County through Sanilac, Lapeer, Oakland, Livingston, and Washtenaw to Hillsdale County. The highlands of this region are all much freer from frost than the lowlands, and all much more favorable for early vegetation. He does not state that any point is high enough to be above the thermal belt, but that, in general, two equal parallel thermal belts inclose the cold island between them.

It is generally conceded that these thermal belts depend both upon the drainage of cold air downward into the lower valleys and the freedom of radiation from the surface of the ground to the clear sky overhead. During a still night, when frosts occur, the surface of the hillside cools by radiation, and hence cools the air in contact with it; the latter flows downward as long as its cooling by radiation and conduction exceeds its warming by compression. Inasmuch as its cooling depends on contact with a still colder soil or plant, it soon accumulates in the lowlands as a layer of cold air, which grows thicker during the night by the steady addition of the thin layer of descending air in contact with the ground on the hillsides. The warmer air, which has not yet had an opportunity to cool by contact with the ground, floats on top of the cold mass; it spreads out toward the hills, and is continuously furnishing its heat to the adjacent hillsides as fast as it comes in contact with them before it also cools and descends. The formation of the thermal belt seems to depend largely upon this gentle circulation during the nighttime. The lower limit of the belt is defined by the depth of the accumulation of cold air in the confined valley and rises higher in proportion as the night is clearer and longer, and also in propor-

> tion as the valley is more or less perfectly inclosed. The upper limit of the thermal belt may depend upon the strength of the wind and the general temperature of the air. But if there be no wind, then it depends equally on the freedom of radiation to the clear sky and on the above-described circulation of air.

The facts quoted in this article show that frost may be expected on low grounds at times when higher grounds escape the visitations, and the lesson they teach is that early and tender crops should, so far as may be practicable, be confined to crests, hillsides, and mountain sides, and later and hardier crops to the lowlands and valleys.

Local climate, as it is influenced and regulated by the proximity of bodies of water, must be given great weight in calculations regarding frost. Frost is less likely to occur in localities swept by moisture-laden air which has crossed a considerable body of water. This is more especially the case in the fall of the year, when the temperature of bodies of water is reduced very slowly; and in the South, where the water temperature continues relatively high throughout the year, the influence of the water is especially marked. During the colder months air is not only warmed in crossing considerable bodies of water, but it also absorbs moisture, which, although invisible in the form of water vapor, has the effect of retarding the radiation of heat from the earth. In fact, so pronounced is the influence of water and water vapor that localities which with reference to exposure to west and northwest winds are, as it were, in the lee of large bodies of water are comparatively free from frost visitations. On the keys of the east Florida coast which are protected on the west by lagoons, rivers, lakes or bays, frost is said to be unknown, and throughout the central and northern sections of the United States, localities which are protected on the west and northwest by bodies of water of considerable size are not only favored, by reason of their position, with conditions which do not promote the formation of frost, but also receive the benefits derived from heavier falls of snow.

Local soil conditions constitute, to a certain extent, a factor in the formation of frost. As a rapid loss of heat is promoted by an active evaporation of moisture, it is evident that, with other conditions equal, frost is more likely to occur on damp than on dry ground, provided, however, that the ground is not too moist, for in the latter event the amount of moisture evaporated and added to the air would have a tendency to retard the radiation of heat from the earth. And herein lies the distinction, so far as frost formation is concerned, between moist air and moist soil. An excess of moisture in the air, in preventing, to a degree, the radiation of heat, is unfavorable to the formation of frost. As frost is the moisture of the air in immediate contact with the earth condensed at freezing temperature, it follows that the earth, from which the moisture of the air is drawn, must contain more or ss water, and it is evident that damaging frost will occur with a mited rather than with a large quantity of moisture arising from the arth and a moderately moist and comparatively still air. Both of these conditions usually obtain following, but not too closely following, the rains of spring and autumn. The character of the soil as regards its capacity for retaining moisture must also be taken into account, more especially during periods of comparatively dry weather. Moist soil, and the vegetation which springs from it, is chilled to a lower temperature by the evaporation of moisture, and is therefore more subject to visitations of frost than soil which is dry, or into which water penetrates deeply, leaving the surface dry, or soil which sheds the rain and does not absorb and hold water. It is important to note, however, that very moist soil, or soil which contains a large amount of surface water, is, owing to the quantity of moisture yielded to the air, not so subject to the heavy and damaging frosts which visit plants on moderately damp ground or ground that has a small capacity for moisture.

## DATES OF EARLY AUTUMN AND LATE SPRING FROSTS.

The following table shows for stations of the Weather Bureau throughout the United States dates of first killing frost in autumn, and of last killing frost in spring; also the average dates of first killing frost in autumn and of last killing frost in spring:

*Dates of first killing frost in autumn and of last killing frost in spring at Weather Bureau stations throughout the United States.*

| Station. | Date of earliest recorded killing frost in autumn. | Date of latest recorded killing frost in spring. | Average date of first killing frost in autumn. | Average date of last killing frost in spring. |
|---|---|---|---|---|
| Eastport, Me | Sept. 3 | June 19 | Oct. 12 | Apr. 28 |
| Northfield, Vt | Aug. 27 | June 7 | Sept. 16 | May 13 |
| Portland, Me | Sept. 11 | May 31 | Oct. 18 | Apr. 14 |
| Boston, Mass | Sept. 30 | May 11 | Oct. 23 | Apr. 26 |
| Nantucket, Mass | Oct. 1 | Apr. 24 | Nov. 5 | Apr. 10 |
| Block Island, R. I | Oct. 30 | May 11 | Nov. 16 | Apr. 18 |
| Narragansett, R. I | Sept. 21 | May 30 | Oct. 16 | Do. |
| New Haven, Conn | Sept. 15 | do | Oct. 17 | Apr. 20 |
| Binghamton, N. Y | Sept. 16 | May 21 | Oct. 6 | Apr. 27 |
| Albany, N. Y | Sept. 23 | May 30 | Oct. 17 | Apr. 24 |
| New York, N. Y | Oct. 15 | Apr. 30 | Nov. 6 | Apr. 10 |
| Harrisburg, Pa | Oct. 3 | Apr. 28 | Oct. 24 | Do. |
| Philadelphia, Pa | do | Apr. 29 | Oct. 30 | Apr. 8 |
| Atlantic City, N. J | Oct. 1 | Apr. 25 | Nov. 4 | Apr. 11 |
| Baltimore, Md | Oct. 6 | May 3 | do | Apr. 4 |
| Washington, D. C | Oct. 2 | May 11 | Oct. 21 | Apr. 7 |
| Lynchburg, Va | Oct. 4 | May 7 | Nov. 1 | Apr. 14 |
| Norfolk, Va | Oct. 15 | Apr. 26 | Nov. 12 | Mar. 27 |
| Wytheville, Va | Sept. 14 | May 26 | Oct. 7 | Apr. 23 |
| Charlotte, N. C | Oct. 8 | Apr. 26 | Nov. 4 | Apr. 1 |
| Raleigh, N. C | do | May 6 | do | Apr. 5 |
| Hatteras, N. C | Nov. 7 | Apr. 19 | Dec. 11 | Feb. 28 |
| Wilmington, N. C | Oct. 16 | May 1 | Nov. 15 | Mar. 27 |
| Charleston, S. C | Nov. 9 | Apr. 2 | Nov. 30 | Mar. 1 |
| Columbia, S. C | Oct. 19 | Apr. 17 | Nov. 8 | Mar. 23 |
| Augusta, Ga | Oct. 8 | do | Nov. 9 | Mar. 20 |
| Savannah, Ga | Nov. 1 | Apr. 5 | [illegible] | [illegible] |
| Jacksonville, Fla | Nov. 12 | Apr. [illegible] | | |
| Jupiter, Fla | Nov. 18 | Apr. [illegible] | | |

*:s of first killing frost in autumn and of last killing frost in Weather Bureau stations throughout the United States*—Conti

| Station. | Date of earliest recorded killing frost in autumn. | Date of latest recorded killing frost in spring. | Averag date o first ki ing fro in au- tumn. |
|---|---|---|---|
| ıta, Ga | Oct. 4 | Apr. 10 | Nov. |
| n, Ga | Nov. 5 | Apr. 18 | Nov. |
| pa, Fla | Nov. 28 | Mar. 19 | Jan. |
| ıcola, Fla | Nov. 12 | Apr. 6 | Dec. |
| le, Ala | Oct. 31 | Mar. 28 | Nov. |
| gomery, Ala | Oct. 21 | Apr. 5 | Nov. |
| lian, Miss | Oct. 8 | Apr. 10 | Nov. |
| burg, Miss | Oct. 19 | Apr. 6 | Nov. |
| Orleans, La | Nov. 19 | Mar. 27 | Dec. |
| veport, La | Oct. 20 | Apr. 2 | Nov. |
| Smith, Ark | Oct. 15 | Apr. 6 | Nov. |
| Rock, Ark | Oct. 22 | Apr. 14 | Nov. |
| tine, Tex | Oct. 20 | May 30 | Nov. |
| ston, Tex | Dec. 4 | Mar. 1 | Dec. |
| Antonio, Tex | Nov. 9 | Mar. 20 | Nov. |
| us Christi, Tex | Nov. 30 | Mar. 19 | Dec. |
| phis, Tenn | Oct. 2 | Apr. 16 | Oct. |
| ville, Tenn | Oct. 8 | May 14 | Oct. |
| tanooga, Tenn | Sept. 30 | do | Oct. |
| xville, Tenn | Oct. 1 | Apr. 24 | Oct. |
| sville, Ky | Sept. 24 | May 14 | Oct. |
| ngton, Ky | Sept. 30 | May 20 | Oct. |
| sville, Ind | Sept. 10 | Apr. 21 | Oct. |
| napolis, Ind | Sept. 21 | May 21 | Oct. |
| nnati, Ohio | Sept. 30 | Apr. 24 | Oct. |
| mbus, Ohio | Sept. 21 | May 17 | Oct. |
| s, W. Va | Sept. 28 | May 24 | Oct. |
| ersburg, W. Va | Sept. 24 | May 22 | Oct. |
| burg, Pa | Sept. 25 | May 29 | Oct. |
| go, N. Y | do | do | do. |
| ester, N. Y | Sept. 26 | May 30 | do. |
| ılo, N. Y | Sept. 23 | May 25 | Oct. |
| Pa | Oct. 12 | May 17 | Oct. |
| land, Ohio | Oct. 2 | May 22 | Oct. |
| lusky, Ohio | Oct. 8 | May 2 | Oct. |
| lo, Ohio | Sept. 9 | May 29 | Oct. |
| oit, Mich | Sept. 21 | May 31 | Oct. |
| Huron, Mich | Sept. 22 | June 6 | Oct. |
| ıa, Mich | Sept. 6 | June 9 | Sept. |
| Ste. Marie, Mich | Sept. 5 | May 29 | Sept. |
| uette, Mich | Aug. 22 | June 11 | Oct. |
| naba, Mich | Sept. 9 | June 16 | Oct. |
| Bay, Wis | Sept. 16 | May 30 | Oct. |

*of first killing frost in autumn and of last killing frost in spring at Veather Bureau stations throughout the United States*—Continued.

| Station. | Date of earliest recorded killing frost in autumn. | Date of latest recorded killing frost in spring. | Average date of first killing frost in autumn. | Average date of last killing frost in spring. |
|---|---|---|---|---|
| ity, S. Dak | Sept. 13 | May 20 | Sept. 20 | May 1 |
| Wyo | Aug. 23 | June 18 | Sept. 11 | May 19 |
| ke City, Utah | Sept. 22 | do | Oct. 18 | Apr. 23 |
| unction, Colo | Sept. 14 | Apr. 30 | Oct. 29 | Apr. 11 |
| e, Wyo | Aug. 29 | June 11 | Sept. 16 | May 22 |
| latte, Nebr | Sept. 10 | May 23 | Sept. 28 | May 1 |
| Colo | Sept. 12 | June 6 | Oct. 7 | May 6 |
| , Tex | Oct. 16 | May 23 | Nov. 1 | Apr. 16 |
| Colo | Sept. 12 | do | Oct. 5 | Apr. 26 |
| Kans | Sept. 23 | May 11 | Oct. 15 | Apr. 17 |
| na, Okla | Oct. 7 | Apr. 30 | Oct. 31 | Apr. 2 |
| rth, Tex | Oct. 22 | May 1 | Nov. 19 | Mar. 18 |
| Tex | Oct. 25 | Apr. 16 | Nov. 15 | Mar. 15 |
| , Tex | Oct. 30 | Apr. 22 | Nov. 10 | Mar. 20 |
| e, N. Mex | Sept. 28 | May 18 | Oct. 19 | Apr. 15 |
| riz | None. | None. | None. | None. |
| , Ariz | Nov. 9 | Mar. 31 | Dec. 7 | Feb. 18 |
| e, Wash | Sept. 7 | June 8 | Oct. 17 | Mar. 23 |
| alla, Wash | Sept. 28 | May 3 | Nov. 1 | Apr. 6 |
| Wash | Oct. 18 | May 10 | Nov. 22 | Mar. 21 |
| d, Oreg | Oct. 13 | May 9 | Nov. 16 | Mar. 17 |
| Island, Wash | Nov. 1 | Apr. 19 | Dec. 15 | Mar. 14 |
| g, Oreg | Oct. 9 | May 16 | Oct. 30 | Apr. 15 |
| ity, Oreg | Sept. 4 | June 24 | Sept. 27 | June 3 |
| ucca, Nev | Aug. 22 | May 11 | Sept. 24 | June 20 |
| Cal | Nov. 7 | May 1 | Dec. 8 | Apr. 2 |
| ff, Cal | do | Apr. 9 | Nov. 25 | Mar. 15 |
| ento, Cal | Oct. 28 | Apr. 26 | Nov. 15 | Feb. 16 |
| ncisco, Cal | Dec. 20 | Apr. 20 | Dec. 13 | Jan. 25 |
| Cal | Nov. 18 | Apr. 14 | Dec. 15 | Mar. 4 |
| s Obispo, Cal | Nov. 19 | Apr. 8 | Dec. 17 | Mar. 17 |
| eles, Cal | None. | do | None. | Apr. 8 |
| go, Cal | None. | None. | None. | None. |

## PROTECTION FROM FROST.

liscussion of methods of protection from frost calls for a considn in great detail, not only of the several approved processes of ction and the extent to which they can be applied in connection the various crops, but also the value of these processes under the ng conditions of local topography, local climate, and local soil tions.

s evident, in the light of the foregoing statements, that fruit and able growers in rolling and hilly country, or when located in the regards west to northwest winds, of bodies of water, can, to some t, so place in their earlier and tenderer fruits and crops that they in the first instance, avoid the lowlands and valleys, and in the d take advantage of the more moderate and moist air that crosses surfaces. For further protection the grower must depend upon cial appliances. These appliances are designed to produce the ving effects or results: To prevent a rapid radiation of heat from rth; to charge the air with moisture; to warm the air; to create cial drafts, whereby the air is mixed and the cold air is not ed to settle to the surface of the earth; or to actually cover or in plants.

## DEVICES FOR PREVENTING RAPID RADIATION OF HEAT.

Devices designed to prevent a rapid radiation of heat from the earth include screens which can be drawn over plants, vineyards, and groves; loose substances with which low plants may be covered; and smudge fires built to the windward of areas for which protection is desired. These devices, which of a necessity are operative for very limited areas, are described by Professor Hammon in Bulletin No. 23, Weather Bureau, as follows:

**Glass screens.**—In greenhouses and hotbeds advantage is taken of the peculiar property of glass which allows the heat rays of the sun to pass through it, and is almost impervious to the dark *heat* rays from the earth and plants. This is one of the most perfect screens possible, since it not only prevents the loss of heat by radiation, but receives and retains the heat from the sun. The expense precludes its adoption except for the protection of valuable plants and flowers.

Screens of other solid materials have been quite extensively used in protecting vineyards and citrus groves where intense cultivation is practiced and where the location of the groves near an excellent market admits of profit even with expensive methods of cultivation.

**Cloth screens.**—In Italy and portions of France screens made of muslin strung on wires stretched on poles above the tops of trees or vines have been used extensively. These screens are drawn on nights when frosts are probable, and are pushed back during the day. When the season has advanced so far as to preclude further danger, they are taken down and stored. Of course such a plan could be operated only on a very limited scale, and would then be expensive. This plan has been recently successfully tried in the orange groves of southern California.

**Lath screens.**—During the past few years screens made of laths fastened to ordinary telephone wire (the spaces between them being about the width of the laths) have been extensively used in Florida. These are spread over a frame erected above the trees or plants. The screens serve not only as a fair protection from frost, but also as a shade from the hot sun. When no longer needed, they can be rolled up and stored away for preservation. At first thought it would seem improbable that a screen covering only half the space (the spaces being as wide as the laths) would afford much protection; but when it is considered that laths have considerable thickness it is plain that while only one-half the vertical rays are screened those inclined between the vertical and horizontal are partially intercepted by the edges as well as the faces of the laths. As a matter of fact, about three-fourths of the sky is screened by this means. By placing the laths in north and south directions the direct rays of the morning sun are completely cut off from the orchard, which admits of the temperature rising slowly. This reduces the liability of injury to plants.

**Other methods.**—Strawberries and other low plants are frequently protected by covering them with straw or other loose substances.

Frequently young potato plants are saved by plowing a furrow alongside and allowing the dirt to bury them.

Cranberry growers in the marshes of Wisconsin flood the marshes when frost is expected. In this case the protection is probably due, for the most part, to the high specific heat of the water, as only portions of this land are submerged.

**Smudge fires.**—Since on cloudy nights radiation is so reduced as to prevent the formation of frost, many have thought that an artificial obscuration of the sky by means of dense smoke would be an excellent means of protection. The efforts of this character which have been made have resulted in decidedly varying success. In the wheat fields of the Dakotas excellent protection was obtained in limited areas, while the experience of orchardists in Florida and southern California has not shown such uniform success.

Since it was supposed that the protection resulted from the obscuration of the sky by means of smoke, the best protection was expected from the use of that fuel which would produce the greatest smoke.

In the Dakotas the best and most convenient material at hand was the straw of the previous year's crop, which had been left in the fields all winter and through the rainy spring, until it was quite thoroughly soaked with water.

In southern California and Florida straw was scarce, and where it could be obtained it was much drier than that used in the Dakotas. Consequently tar, crude petroleum, and other similar smudge materials were substituted; but the results have not been, as a rule, satisfactory, although the smoke was equally dense. However, quite successful results were obtained by Mr. Buck, Mr. La Rue, and others in the Vacaville and Sonoma sections by burning damp stable manure in sacks scattered throughout the orchard.

Devices for preventing a rapid radiation at night of the heat absorbed by the earth during the day can be utilized only for comparatively small areas. The screen devices, also, by reason of their cost, are available only for the smaller orchards and vineyards whose products command early market prices; the same may be said of coverings of straw and other materials for strawberries and other low plants. Smudge fires can be used to advantage for orchards, vineyards, and ground plants, and even for the smaller grain fields, and would be particularly efficacious in protecting crops and plants in low or bottom lands over which, on still nights, the smoke from smudge fires would settle. There is no device at present known that will, by preventing a rapid radiation of heat, afford any material protection to the great grain fields of the West and Northwest.

## DEVICES FOR ADDING MOISTURE TO THE AIR.

Smudge fires made of damp material have been more successfully used for the purpose of affording protection from frost than those made of tar, crude petroleum, and other dry materials, for the reason that in addition to creating a dense smoke they add to the atmosphere a considerable amount of evaporated water, which, though invisible, serves to retard the radiation of heat. When any considerable amount of water is thus converted into vapor and is distributed in the air which covers the area to be protected, a portion of it is likely to be condensed by the surrounding cooler air and appear in the form of mist, which acts as an agent to prevent the escape of heat from the earth; and the act of condensation sets free in the air some of the heat that has been expanded in the process of evaporating the water contained in the smudge-fire materials. Thus the process is

or pall, and the moist air which overlie the grou
presence the safety of the plants from frost depen

As smudge fires made from damp materials ar
nized devices which have been found to be more
affording protection from frost, the following des
which have been adopted for utilizing them in
from Bulletin No. 23, already referred to:

**Fires of damp straw and stable manure.**—Have the fu
tributed throughout the orchard in advance; the more n
better. With the same amount of fuel the best protection
and frequent fires, since with small fires the upward dra
imum, and the more frequent the fires the more uniform
of heat.

**Sacks of manure.**—A decidedly preferable method is
manure in common grain or burlap sacks, by which i
handled. They should be distributed through the orcha
feet apart and about 50 feet between sacks in each row.
sary to protect, a small amount of coal oil is poured upon
It is usually unnecessary to fire more than every second
mainder being left for later occasions. These sacks will b
fire for several hours.

The amount of heat which is set free by burning one sa
about 50 pounds and condensing the water vapor near th
cient to raise the temperature 20° in a space 75 feet squar
one-fourth of this heat remained within this region nee
seems to be a reasonable estimate, ample protection would
any ordinary conditions.

**Bales of wet straw.**—Mr. T. A. Morrison, of Riverside,
of a similar plan, in which bales of wet straw were su
This plan has been tried with fair success. One hundre
in four pieces, a tie wire being left about each piece, and

First. The fire can be moved to the section where most needed, which is generally along the windward side of the orchard.

Second. The loss of heat by an upward draft is almost entirely prevented, since the fire does not remain in one position long enough to establish such a draft. On this account much larger and, consequently, fewer fires, with equal efficiency, are possible.

Third. There is a much more uniform distribution of heat and smoke throughout the orchard.

As smudge fires prepared and applied in the manner above indicated are inexpensive, to a degree effective, and easy of operation, they constitute the method which for practical use and utility seems best adapted for general use in orchards, vineyards, gardens, truck farms, and small fields, as a protection from frost. Among the many devices that have been employed for holding and carrying these fires the following has been used with especially satisfactory results by a fruit company of Visalia, Cal., and will doubtless prove equally effective in other sections:

> Wire frames (chicken-yard fencing) are built on low truck wagons and stretched from four wagon stakes and heaped over with wet manure. Dirt is then thrown on the wagon beds to protect them, and pots of burning tar are set underneath the straw roof. A barrel of water on the wagon is used to keep the straw wet. The wagons are driven about and do the best work, as they can go wherever the most needed. The smoke and vapor are carried to the rear as the wagon moves, and, being carried at once out of the rising heat, fall close to the ground in a long, white trail. At daylight 400 acres of orchard are covered with a white fog, extending from the ground to about 20 feet high. Similar fires are used as stationary smudges, the wire netting being stretched between four stakes driven in the ground.

Crude petroleum, supplied to a burner from a tank on a wagon or truck, has been used with success by Mr. R. H. Howard, of Riverside, Cal. Over the burner is placed a large wire basket containing mineral wool, which is kept saturated with water supplied by a tank, also placed upon the wagon. Wet straw and manure can also be used. The apparatus can be driven where most needed. The burning coal oil gives off a dense smoke, while the wet mineral wool furnishes a vast surface from which evaporation can take place, and at the same time the material will not be consumed.

### DEVICES FOR CHARGING THE AIR WITH MOISTURE.

Aside from the smudge fires, Bulletin No. 23 quotes devices which have been adopted to charge the air directly with moisture, some of which are constructed on a plan too elaborate and expensive for general use.

The first operation involved is the evaporation of water in large quantities, either by means of evaporating pans or by t stance the protection against frost by this method

Sprinkling gardens before sunrise on frosty m of decided value.

Secondly, irrigation, which of necessity can be limited extent and in certain favored localities, afford very complete protection from frost in fi vineyards which are equipped with irrigation cranberry districts of Wisconsin perfect protecti frost is secured by flooding the cranberry mars heavy frost occurs in that section.

In no case should water be allowed to stand in or gardens during the early growing period whil is possible, for the reason that water unduly pro young plants and thereby renders them more su by frost and cold than are the plants whose grow

The third operation involved in the California direct heating of the air by means of fires. It w fires caused a strong upward draft of air, whic drawing in cooler air from the sides, and that we fires were attended by very satisfactory results.

The following final report of the Riverside covers the results of experiments made during the

> With the assistance of fifteen or twenty citizens interes points involved, a most complete test has been made of th ods employed to prevent frost damage. With such a forc partial observers it was possible to secure data of muc estimate of the efficiency of the various plans made use o was made between those orchards where no work was do effect of the fire was probable, and those where the d

ack of definite knowledge as to the directions their efforts should take, neglect reasonable precautions hereafter to insure the safety of their crops. These, however, are our conclusions:

First. There is no doubt whatever that the temperature of our orchards may be materially raised by the use of dry heat.

Second. The radiation of the earth's heat can be considerably lessened by moist smudges, when these are started early enough and are properly managed.

Third. The possibility of raising the dew-point on one of the dry, cold nights peculiar to our climate sufficiently to prevent damage, by means of steam-producing apparatus, seems impracticable.

Fourth. Fruit and trees can undoubtedly be saved, even in the coldest sections, by covering them with cloth or matting, but the expense involved makes this method impossible on the part of the ordinary grower.

Fifth. It is found that the temperature in an old seedling grove, or where tall wind-breaks afford to smaller fruit trees a like protection, the temperature is almost invariably 1° to 2° higher than in exposed orchards in the immediate neighborhood. This fact seems to thoroughly upset the theory, strongly held by many intelligent growers, that the tall, well located wind-break is a disadvantage, the contrary seeming to be the truth.

Sixth. It is found that the temperature 20 feet above the ground is 1° to 2° higher than at the surface, and that, as a rule, when the cold is severe enough to injure the ripest fruit 50 feet from the ground there is almost invariably a temperature above the freezing point of water.

Professor Zumbro, who has given especial attention to this matter, finds that at the height of 50 feet the temperature is from 5° to 10° higher than at the surface when the air is not in motion. When there is any considerable breeze it varies but little.

Seventh. Our conclusion is that, all things considered, the coal baskets, sufficiently numerous, will prove the most satisfactory and effective means of warming the orchards yet made use of. It is true the oil pots make a far hotter fire, and are neither expensive nor difficult to manage; but the deposit of lamp black upon tree and fruit resulting from their use condemns this system for general use.

As to the value of smudging the members of your committee are not so well agreed. Because of less sharply defined results, we find it more difficult to come to definite, at least uniform, conclusions. But, under certain conditions, we are convinced that, properly used, it may be made a valuable means of protection. We think this especially true in localities where the temperature falls only a little below the danger point, and where there are considerable solid areas of young orchards exposed. Here it will work well if the protection is made general. But where the danger is considerable we think it wise to be prepared to use dry heat, even where in connection with the smudge. The benefit from smudging is probably as much from its protecting fruit and trees from the sudden rays of the morning sun after a freezing night as from modifying temperature during the time of danger.

Experience demonstrates that flooding or running water in connection with dry heat or smudging is a valuable adjunct. One of the committee who has been testing this matter carefully for three years is disposed to think that the direct benefit from running water is overestimated by a majority of growers. Its value in putting orchards in condition to withstand quite severe weather safely is questioned, but the committee are inclined to think that entire dependence upon this method will occasionally result in serious loss to
to this means alone, especially when used in young orchards.

As to the number of baskets needed when coal is used, we find that the most decided and satisfactory results have been gained where from twenty to fifty coal fires have been used to each acre. If intelligently and energetically used this plan will never fail, except when the mercury drops below 24° for a long while, and even then it is believed the larger portion of the crop may be saved if anything like a general use of such fires be secured. The smaller number of fires named has, in numerous instances, and even when a man was working alone, secured a rise of from 3° to 5°, and saved a crop. Can it be doubted that 50 fires per acre, used in every orchard, would save both trees and crop on the coldest night ever known in California's history?

To equip an orchard with 50 baskets to the acre means an outlay of only a little over $5. The fuel to run them one night costs from $2.50 to $3. If a crop of navels upon it is worth $400 it will pay well to spend in labor and fuel $4 per night, or 1 per cent on the value of the crop to insure its safety. In the orange region of southern California it is not unusual to have more than two or three nights in a season when the fruit is in danger. But even if, as in the present season, the period of cold is more extended will it not pay to expend at least as much as one pays for his irrigating water to insure the safe maturing of a crop it has cost him a year's labor and heavy expense to produce? The conclusion is obvious that we have only to provide for the insurance of this sort of property exactly as we would in the case of that liable to destruction by fire, to be enabled to follow the business of orange and lemon growing with the certainty of having perfect fruit to market at the season's end.

While the practicability of protecting our orchards from frost seems established, the problem of the most economical and scientific means of accomplishing this is probably yet to be solved. However well the wire baskets may serve us now, there will doubtless be improved method for burning coal, and even other material may be found that will serve the purpose better; and while wet straw seems to be at present the most available for smudges, doubtless, when the need is made known, chemists will find some vapor-producing material more compact, efficient, and economical. Hence we recommend that the club appoint a permanent committee to continue these investigations.

## GENERAL OBSERVATIONS AND PRACTICAL RESULTS.

### WORK IN TEXAS.

In a paper read before the annual meeting of the Texas Farmers' Congress and Texas State Horticultural Society in joint session at College Station, Tex., July 26, 1899, Mr. Joseph L. Cline, observer, Weather Bureau, submitted the following remarks on "The use of frost and temperature warnings in protecting fruits and truck gardens:"

It has been proved that a good way for protecting berry crops is to cover with hay. Berries are improved by mulching. Prairie hay used for this purpose can be cut and placed in the fields, ready for covering the plants when frost is indicated, at a cost of about one dollar a ton. Ten tons per acre are considered sufficient for protection against any freeze. The cost of labor for covering the plants would be about two dollars an acre additional. As the hay is required for mulching, the cost is considerably lessened when the hay is utilized for that purpose. Berry crops which were covered prior to the freeze of last February yielded four times as much as unprotected plants, and unprotected plants were generally killed. Cabbage, potatoes, and other vegetables can be protected from frost by hay, and the increased yield will more than pay for the expense involved. Rice growers along the east Texas coast can raise vegetables throughout the winter on their rice plantations by protecting them from frost. The plantations can easily be flooded during freezing weather, which is always of short duration, and the water would protect and do very little or no damage to the vegetables, which are remunerative during the winter season.

* * * * * * *

The method of burning stakes soaked in petroleum or kerosene oil throughout the fields can be applied not only to the protection of maize, but fruit orchards as well. By means of burning stakes fields will be enshrouded, when the wind is light, in a continuous cloud of smoke. This will, in many instances, prevent frost from occurring. The stakes must not be set so close to the fruit trees that the heat will affect the branches.

* * * * * * *

In France frost bells are sounded when frost is expected, and grape growers protect their crops by pouring tar on the ground among the vines and setting it on fire. The smoke thus made often saves the crop of an entire vineyard. Bituminous coal burned in baskets is less expensive and has been successfully used. Forty to fifty baskets of coal per acre are required, and the more used the better would be the result. Strawberry crops can be protected in this manner at a cost of $4 to $6 an acre.

* * * * * * *

The following letter from Capt. B. F. Johnson, president Gulf Coast Horticultural Association, gives an idea as to what can be done in protecting crops [by showing what was done in February, 1899]:

"I was in Galveston, Tex., on the morning of February 11, 1899, and upon hearing that a freeze was expected I called at the United States Weather Bureau office, and was informed that the hardest freeze of the season was threatened. I immediately gave orders over the long-distance telephone to my employees at Arcadia to cover up all hotbeds and also all plants already transplanted. All the plants in hotbeds were carried through the freeze by protection and saved from injury. I had about 7,500 cabbage plants set out, and on account of my employees not going to work as directed we did not reach these until ice had formed over some of the plants. I took the first train out of Galveston, which was in the afternoon, and upon my arrival at Arcadia we continued protection, notwithstanding the fact that ice had already formed over the plants. We placed a handful of hay over the north side of about 1,000 cabbage, and at least 750 of these came through the freeze uninjured, while all the unprotected were killed. The varieties protected were the Jersey-Wakefield and Henderson-Succession, and I could see no difference between the two after the freeze. Had my employees carried out the instructions given them in the morning I would have saved 75 per cent of the 6,500 unprotected plants which were killed, and this would have yielded me about $150 net. I had 1¾ acres of Irish potatoes planted in January, which were up to fair stand. These were not protected and were all killed. I had about one-sixteenth acre planted with hand planters the 1st of February. These were protected with vines from old sweet potatoes grown on the ground the previous year. Fully one-eighth of these came up after the freeze with this light protection, and thu
me to put the first potatoes on the Texas market, and they
bushel net. If I had been prepared and protected the 1¾ acr
uary I would have received a nice little sum, and more t

cost of protection. Strawberries not mulched were virtually killed, while those mulched made an average crop. The great value of protection to berries in case of freezing weather has been forcibly illustrated. The entire crop of early berries (the only berry crop which pays well) would have been a total failure without protection."

* * * * * * *

The following communication of Mr. M. M. Cox, president of the League City Truck Growers' and Farmers' Association, League City, Tex., gives further the manner and value of protecting crops from the frost and freeze during the abnormally cold weather of February 12 and 13, 1899. Mr. Cox says:

"I had two acres of strawberries—Noonan and Mitchell varieties—which were blooming and fruiting nicely. In anticipation of a freeze we placed hay for mulching purposes between the rows, which were about 3 feet apart. Upon the receipt of the telegram, Saturday morning, February 11, 1899, announcing the approach of a freeze, I got word to the man who had charge of my berry crop. He immediately went to covering the vines with hay previously placed in the berry patch and succeeded in covering 20 rows. The vines of the protected berries were practically uninjured, while the unprotected plants were frozen to the ground and many of them totally killed. From these 20 rows, about one-fourth acre of protected plants, we picked berries nearly three weeks before the unprotected berries were ready for market. The one-fourth acre of protected berries yielded me more than the remaining 1¾ acres altogether. In fact, we got the bulk of our crop—a little more than $300 net—off this one-fourth acre. If we had used more hay for covering we could have saved the blooms and berries already on the vines notwithstanding the severity of the freeze, as some berries were saved as it was.

"Others in League City protected berry crops with the same results as those which attended our protection.

"Hotbeds protected for ordinary freezes were killed, but some put extra covering on the beds, using blankets, and thus saved their plants without injury. Those who protected in this manner were setting their plants in the field while others were sowing seeds in the hotbeds, and were thus at least four weeks ahead with their crops for the market.

"The warnings of the Weather Service promise much for the coast country."

Mrs. C. W. Benson, Alvin, Tex., in writing of protection of crops, says:

"In past seasons the advance notices of frost and freezing weather given out by the United States Weather Bureau have been distributed among the truck growers by messenger service, and by this means have saved our planters who protect their crops thousands of dollars.

"In 1899 all crops were carried through safe until the severe freeze of February 11, and in several instances tender crops were successfully protected and carried through this freeze even when the mercury stood at 4 degrees above zero or 28 degrees below the freezing point. The principal crops protected were tomatoes, cucumbers, cabbage, and strawberries. The three first mentioned were still in hotbeds or cold frames, and were protected by covering with hay to a depth of about 1 foot, over glass or canvas. Berries were protected by turning over mulch and covering up plants from 4 to 6 inches in depth. This mulch had already been placed between the rows to retain moisture and keep the berries clean on plants. This protection did not save blooms, but the plants so protected came through the freeze with much less damage and produced more fruit than the unprotected plants. I judge that the protection was fully worth $30 per acre, as prices of berries remained firm all through the season on account of general scarcity of fruit. About 25 acres were thus protected from the freeze.

ıe value of the tomato crop saved through protection from this freeze ged fully $125 per acre in spite of the subsequent drought, which extended February 14 until after the crop was marketed, with the exception of a ight showers, which were insufficient for general growth of plants. With s in an average season the crop would have paid $250 per acre, and enough were carried through this freeze by protection to set 17 acres.

out 200,000 cabbage plants were carried through this severe freeze of ary and successfully transplanted. These would have netted the growers with sufficient rain during the growing period. The value of the cucum- op from actual results was about $1,000, which would have increased er cent in an ordinary season, but they were held back for lack of moisture he north Texas crop was on the market, as cucumbers which sold at from 0 cents per one-third bushel box would have netted from 75 cents to $1.25 zen.

otection of crops enables the grower to generally reach the first markets, ithout the advance notices of frost and freezing weather it would be im- able to protect; our people would bear the expense of the warnings than do without them."

## WORK IN LOUISIANA.

bably the most extensive experiments for the protection of fruits in the Southern States have been conducted in a large e orchard near Diamond, La., under the management of Mr. tt Chapman. In the Report of the Louisiana Section of the ate and Crop Service of the Weather Bureau for February, this grove and some of the methods employed to protect its are described by Mr. Alexander G. McAdie, of the Weather au, as follows:

orange orchard is about 43 miles south of New Orleans, near the river, out 20 miles north of what is considered the safe orange belt of Louisi The grove covers 130 acres and contains 15,000 trees, including Creole s, Mandarins, and Satsumas; sweets budded on Trifoliata and Pomeloes r stock. These young trees withstood the frosts of January 1, December 0, 11, 1898. The writer visited this grove on December 11, when ice one r inch in thickness could be found along the roads and in exposed . The orchard is irrigated by means of river water carried over the levee direct-acting pump, 6 by 8, worked by a 40-horsepower boiler. The dispenses with belt, pulley, and engine. To flood the whole orchard of es to a depth of 1 inch would require 5,650 tons of water, or 1,357,700 s. Barely one-hundredth part of this quantity of water is required. The pumped from the river over the levee goes into a main ditch, from which bditches, each subditch feeding two small inlets through the orchard be each line of trees. The distance between the trees averages 17 feet. The ground is cultivated and level so that the water can run in a steady to and out through the quarter drain into the drainage ditches which acre apart, running parallel into the rear canal.

grove has a northern exposure; fronts on the river; the land runs [illegible] st, falling slightly from the river; and there are no wind breaks. It is roposed at this orchard to experiment with the various types of smudges ortion, about 10 acres in extent, will be protected by smudge fires, some le and some stationary. In another section, covering about 30 acres,

the bodies and lower portions of the orange trees are to be wrapped
hay. In the third section the dirt is to be hilled up about the tree
the fourth the trees are to be wrapped with floor matting.

In the methods described above for the protection of trees it was th
colder weather than that of February, 1895, was not likely to occur
appears that the pumping plant, on which great reliance was place
cessfully hold back the trees up to about February 2, 1899, but the
warm weather of the 3d, 4th, and 5th started the sap and forced g
is doubtful, however, whether water protection is adequate under s
tests. All the orange trees above ground appear to have suffered
nearly every case the tree being killed. Those trees which were
with matting likewise suffered and the protection again appears to
inadequate to withstand such extreme cold. In the section where
was hilled up around the trees the results were very satisfacto
thought that about 4,000 trees have been saved by this means. An
of the orchards as late as March 5 indicates that notwithstanding th
of the test, there is reason to believe that orange trees can be prot
cessfully by hilling up the earth.

The devices employed in Louisiana, as described above, we
to be an effective protection against damage by frost, and th
tion afforded by irrigation and by wrapping the bodies a
portions of trees with hay was sufficient for ordinary freezes.
the unprecedented cold of February, 1899, the section in wl
was hilled up about the trees was the only one in which tree
serious injury.

## WORK IN FLORIDA.

Devices used in Florida for the protection of fruit, vegeta
berries from frost and light freezes conform in character
tested in the California experiments, in which fires were fou
the most effective means of protection, and appliances for

in groves and gardens. Berries and other low plants can be pro-
ed with but little expense by coverings of straw and other light
erials. In Florida pine needles are successfully used to protect
wberries. Devices for actually heating the free and open air are
nsive, and their value is dependent solely upon a comparatively
air and small, numerous, and well-distributed fires.

Florida many experiments have been made with a view to adopt-
devices which will protect citrus trees and fruits from injury
ng the periods of severe cold which at times visit that section.
fact that these periods of cold are infrequent does not relieve the
er from the necessity of providing for their occurrence. Effective
sures of protection necessarily vary with the conditions that con-
t the grower. Protection can be made effective by tents, cover-
of cloth, sheds, and one-half and one-third lath shelters and their
ifications, that retain heat from open wood fires and sheet-iron
es. The expense of these methods is obviously too great to make
employment, except for choice varieties of fruit, commercially
table.

this State protection of citrus trees and fruit in the open field
ually afforded by what is known as "firing." This method is
tive, except in the presence of severe freezes, provided rain or
ng winds do not accompany the cold. Heavy rain will, of course,
nguish the fires, and strong winds will not permit a necessary
mulation of warm air about the trees. When no rain is falling
the wind is light, fires must be built on the windward side of the
s, so that the heat will be carried through the trees, and the num-
of the fires must be regulated by the degree of cold. In this form
protection the grower must lay in and place his materials for
ing" before the winter season sets in, and must, during the sea-
be on guard to utilize the materials (usually wood) that he has
mulated. When local indications point to dangerously low
peratures, or when warnings have been received from the Weather
eau, he should watch his thermometers, exposed in the groves,
be prepared to "fire" with a rush when the mercury sinks to
danger point, 28°, with a downward tendency. There is no time
he eve of a freeze to collect firing materials, and the grower must
desert his grove for bed or board so long as danger by cold con-
es. He will have his hands full keeping his fires going, even if
as sufficient material for that purpose. Material should be
able for at least three nights. Cold spells seldom last longer.
danger increases with the length of the cold spell. Trees and
become chilled and the last night of a cold spell is likely to be
ne that does the damage. The freeze of December 23–27, 1906,
d five nights, and in some sections the last night produced the

lowest temperatures of the period. In some localities growers had exhausted their supply of firing material and, as a consequence, suffered a loss of fruit and young trees.

In cases of severe cold fruit can not be saved, and trees can be preserved only by banking up the trunks by sand or soil. Small trees can be buried, and older trees can at least be protected above the parts where they have been budded.

The damage that will result from a given degree of cold varies with the condition and size of the tree. Well-grown trees in a dormant condition will stand without serious injury, except to foliage, a temperature of 18° to 20°, provided it is not too long continued. When the sap is flowing these temperatures are likely to kill growing trees, and are apt to cut small, unprotected trees to the ground. Well-grown trees in a dormant condition will stand without injury a temperature of 26° of continued cold, and can for several hours stand temperatures of 22° to 24°. When the sap is flowing these temperatures continued for several hours will be more or less injurious. Cold that will freeze fruit will injure small trees. In the freeze of December 23–27, 1906, temperatures in parts of the orange belt fell to 20°, and even to 18° and below on one and in some cases two nights without injury to large trees, except to foliage, and with a surprisingly small loss of fruit and small trees. This freeze had been preceded by about two months of rainless weather, and found the trees in a dormant condition. The destructive freezes of preceding years usually followed periods of wet weather that promoted a flow of sap.

Slight protection can be afforded groves by running water in irrigation ditches, or by spraying the trees with water, each process imparting some warmth to the air that is derived from water that is much warmer than the air during a cold spell. As it is not, as a rule, possible to run water in ditches made in Florida sand the irrigation method possesses little value in that State. There are precautionary measures that may in some instances be employed to advantage. In setting out a grove there should be left, where possible, forest trees on its north and west sides where they will act as windbreaks during cold spells. High fences are sometimes employed as windbreaks. Theoretically cold air drains from high to low ground, and groves on elevated sites are more safely located than those on low ground. Protection should also, where possible, be given by water surfaces on the west and north of groves.

### FROST SEASONS FOR SEVERAL CROPS.

Damaging frost is likely to occur in northern Florida as early as the middle of October and as late as the early part of April. During the winter period severe freezes occasionally occur in middle and northern portions of the State, and at rare intervals freezing temperature is experienced to the southern end of the peninsula. Except on the keys and near the coasts of the peninsula south of about the 27th parallel, pineapples can not be safely grown in the open field. When grown in the interior north of that parallel, or on the more northern coasts, they should be afforded means of protection. This is usually furnished in the form of one-half or one-third lath shelters built over the field. Fancy varieties are often grown under glass. Strawberries are subject to damage during the winter and early spring; oranges from December to the early part of February, and orange trees are subject to damage by freezes during December, January, and February. Garden truck is especially subject to injury from January 1 to April 15. In the trucking districts of the interior of the Gulf and South Atlantic States the period during which damaging frost is likely to occur extends from October to April, inclusive.

Temperature conditions are of great importance in the culture of rice, and a severe frost late in October may injure the grain so much as to cause its discoloration. Owing to the manner of growth and culture of this crop and the character and extent of the fields it covers, practically nothing can be done to avert injury from heavy frosts that may occur about the time of harvest.

Tobacco growers may protect their plant beds by coverings, but during the critical periods following transplanting and approaching harvest severe frost will ruin plants in fields which are too large for the successful application of the devices herein described. During the maturing season tobacco plants in large fields can be given protection from damage by frost only by cutting and "frost heaping" on the eve of the occurrence of frost.

Cotton will be seriously injured by low temperature early in the spring whether frost occurs or not. Owing to the area covered by the fields, no adequate means of protection against cold and frost, suitable for general use, has been discovered.

In Louisiana sugar cane is planted in the fall, winter, and early spring. The plants are often killed or seriously injured by frosts in the spring and in October and November. When frost is expected, the cane can be cut close to the ground and "mattressed," the product of three rows being so laid together that the leaves of one armful will cover the butts of the preceding; being thus thatched the canes are protected from frost and will keep in this state for several weeks without injury.

In the cranberry districts of New Jersey, Cape Cod, and Wisconsin, and in limited areas in other parts of southeastern New England, and
the upper lake districts, which are devoted to c
ing is the only effective means of protection
This crop is confined to swamp or bog lands.

frost is apprehended appliances for letting in a sufficient quantity of water to keep comparatively warm and moist the lower stratum of air are usually provided.

Young potato and tomato plants can be saved from damage by frost by a covering of dirt. In large patches this can be accomplished by plowing a furrow alongside the rows of plants and allowing the dirt to bury them.

Gardens can be protected from frost by coverings of straw, paper, or other loose and light materials, or by damp smudges; and the latter device appears to be, in point of effectiveness and cost, the best adapted for general use not only for small areas devoted to gardens, but also for orchards, vineyards, and fields. The effectiveness of any method of protection is of course decreased as the area for which protection is desired is increased, and there is no process yet devised that can give adequate protection against frost and cold in the great grain fields of the country.

## CONCLUSIONS.

Experiments and observation seem to establish the following facts: The danger of damage from frost can be materially lessened by placing early and tender plants on high grounds and crests, and hardier plants in low grounds and hollows. When ground can be selected in the lee, or to the south and east of considerable bodies of water, the danger will be further lessened.

In the dry climate of the citrus fruit region of California and in the promising fruit districts of Arizona small and numerous fires, preferably of coal burned in iron baskets, have been found to be the most effective device used for protection against frost; second in point of utility may be placed irrigation; and the practicable process which affords the least protection in that district appears to have been smudge fires. As before stated, the unsatisfactory character of the experiments made with smudge fires may be attributed to the fact that artificial devices are inadequate to charge dry air with sufficient moisture to prevent loss of heat from the earth by radiation. Reports of California experiments do not distinguish between frosts and freezes. Owing, however, to the usually moderate character of the cold periods of that section the devices referred to would doubtless be equally effective against frosts and freezes.

In the orange-growing districts of the South irrigation affords the most effective protection against frost, while in sections where this process can not be employed damp smudge fires for frosts and light freezes, and wood fires for moderate freezes, properly handled are best adapted to general use. Severe freezes which kill or injure the trees can be guarded against only by housing the trees and heating onfined air, or by "banking up" the trees with dirt or sand. atter method is comparatively inexpensive and is therefore the : adapted to general use.

all sections loose coverings may be used to advantage for pro- ıg low plants, and damp smudge fires may be profitably em- d in gardens, orchards, and small fields.

is important to remark in this connection that none of the arti- devices described should be employed during the growing season ·t on the immediate eve of threatened frost. The necessity for ving this precaution becomes apparent when the fact is consid- that any appliance for protecting plants from cold will main- ıbnormally high temperatures when average weather conditions .il. The effect of this process would be to force the growth of the s and render them the more susceptible to damage by the late ı of spring. In all sections and localities reached by the fore- and special warnings of the Weather Bureau action to put into .tion protective measures can be safely deferred until warning ›s are issued. The Bureau has made provision for a distribution ost warnings which is limited only by the resources of the tele- ı, telephone, mail, train, and signal services, and agriculturists e location renders possible the receipt of the warnings by any e means referred to should adopt measures for securing them. action in this direction would be profitable is shown by the testi- ʳ of those who have received substantial benefits from the ings.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 112.

# BREAD

# AND

# E PRINCIPLES OF BREAD MAKING.

BY

HELEN W. ATWATER.

PARED UNDER THE SUPERVISION OF THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1900.

# LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
*Washington, D. C., January 20, 1900.*

SIR: I have the honor to transmit herewith an article on bread and principles of bread making, prepared by Miss Helen W. Atwater, accordance with instructions given by the Director of this Office. preparing this bulletin Miss Atwater has consulted the available rces of information, including standard works on the subject, and prepared the material for publication under the supervision of ector C. D. Woods, of the Maine Agricultural Experiment Station, o for some time has been immediately concerned with the investiions conducted under the auspices of this Office which have had to with bread and bread making.

Perhaps no topic connected with the subject of human food is of re general interest than bread, and this bulletin, which summarizes most recent information on the subject, is believed to be useful and ely, and its publication as a Farmers' Bulletin is, therefore, respectlly recommended.

Respectfully,

A. C. TRUE,
*Director.*

Hon. JAMES WILSON,
*Secretary of Agriculture.*

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# READ AND THE PRINCIPLES OF BREAD MAKING.

## INTRODUCTION.

There is hardly any food, except milk, which is so universally used bread; and not only is it now known almost everywhere, but since ory first began it has in some form or other made one of the les of diet among all but the most savage peoples. In the earliest orical records it is spoken of, and the wild tribes which to-day bit South Africa know something of its use. Of course the bread de by the Kafir to-day, or by the American Indian three hundred rs ago, is very different from our own. It would be interesting to e the relationship between the bread-making processes of given ples and their rank in the scale of civilization. The Kafir simply nds his grain between two stones, makes a paste of this meal and ter, and bakes it in the ashes of his camp fire; Israel, in Egypt, ate vened bread; the ancient Greeks cultivated the yeast plant; in mpeii an oven was found containing eighty-one loaves of bread not like our own; the Swiss peasant still bakes his weekly loaves in the lage oven; and so on, to the mammoth bakeries and innumerable ncy breads of our own large towns. Such a classification would t be utterly absurd, for except among the lowest savages and in the tremest climates some kind of grain is recognized as a necessary od, and bread furnishes it in one of its most convenient forms—that a form in which it yields the greatest amount of nourishment for least labor and cost. No wonder, then, that the more intelligent eople the better bread they make.

The reason for this importance of bread is very simple. Ever since far-off days when our forefathers first found the wild cereals, or gan to cultivate them, men have known that food prepared from m would support life and strength better than any other single d except milk. The diet of the poor in India and China often sists almost entirely of wheat or millet cakes or rice, and although our own land the ease with which we can get other foods makes ad seem less important, there are still many districts in Europe ere the people eat very little else. To a large part of mankind it is still the staff of life, and if they pray for their daily bread they mean it literally.

In regard to its ingredients, bread is one of the simplest of our cooked foods, but in regard to the changes which the raw materials must undergo to produce a finished loaf, it is one of the most complicated. Flour, water, a pinch of salt, and a little yeast—the necessary things can be counted on the fingers of one hand, yet one of the few books which describes the processes of bread making with any degree of completeness is a large volume of over 600 pages. It is the purpose of this bulletin to give a brief account of these processes—to describe the raw materials from which the bread is made, and the changes which they undergo in the preparation and baking of the dough, with the significance of each to the quality of the bread and its value as food. But before going into a detailed description of these processes it will, perhaps, be well to recall what the main steps in bread making are.

Beginning back in the flour mill, the grain is ground into powder, the coarser parts of which are sifted out as bran, while the finer constitute our flour. Once in the baker's hands, the flour is mixed with water and yeast, or something which will produce the same effect. When this paste or dough, containing yeast, is set in a warm place the yeast begins to "work," as we say, and the dough to "rise;" in other words, the yeast causes a change known as alcoholic fermentation to set in, one of the principal results of which is the production of carbon dioxid gas. If the dough was well mixed, this gas appears all through it, and, expanding, leavens or raises it. After the yeast has worked sufficiently the dough is shut up in a hot oven. Here the heat kills the yeast and prevents further alcoholic fermentation, causes the gas to expand and stretch open the little pockets which it forms between the particles of dough, and changes some of the water present into steam, thus raising the loaf still more. Further, the heat hardens and darkens the outer layers into what we call the crust. The sum of these changes in the oven we call baking. When they have been continued long enough our bread is "done," ready to cool and eat.

## GRAINS AND FLOURS.

Flours, as everyone knows, are made by grinding the grains of the various cereals, wheat, rye, barley, oats, maize, millet, rice, etc. Of these, wheat is the most important partly because it can be cultivated in any temperate climate, but chiefly because it yields the flour best suited to bread making, the aim of which is to produce the most appetizing and nutritious loaf at the least expense. While the various cereals differ largely in their chemical composition, most of them are very similar in the structure of their grains, so that if we study the nation and milling of wheat, we can easily understand the produc- of flour from the others.

## WHEAT.

**ructure.**—The wheat grain (fig. 1) is a small oval seed, which can be ly thrashed from the stalk on which it grows. Its six outer layers known to the miller as the bran. Of these, the three outermost what is called the skin of the grain constitute 3 per cent, by weight, of entire seed. The three remaining rs of the bran form the envelope of eed proper. The outer one is known e "testa," and contains the greater of the coloring matter of the bran. e it lies a thin layer of membrane. e two together form 2 per cent, by ht, of the entire grain. The inner- layer of the bran, called the cereal eurone layer, is made up of rectan- cells, filled with a nitrogenous ance known as cerealin or aleurone. eight is about 8 per cent of that of ntire grain, making the total weight e bran about 13 per cent. In mill- it is exceedingly difficult to separate e three inner layers of the bran. hin the cerealin layer lies the endo- rm, as the portion of the grain adjacent to the embryo is called, ch constitutes the larger part of the grain and consists of irregular ped cells containing starch granules. At the lower end of the grain, ost surrounded by the endosperm, lies the germ or embryo. A tion of the embryo is called the scutellum. This serves a special pose in germination. When the grain has thoroughly ripened and been placed in favorable conditions, this embryo will develop into w plant; as it begins to grow it will feed upon the starch and other tances in the endosperm.

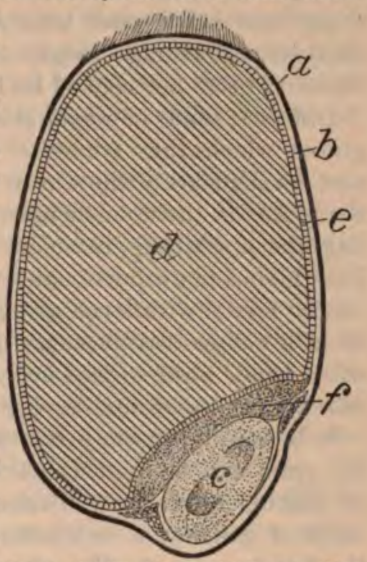

FIG. 1.—Section of grain of wheat: *a*, skins and testa; *b*, membrane; *c*, embryo; *d*, endosperm; *e*, cereal or aleurone layer; *f*, scutellum.

**mposition.**—The five outer layers of the bran contain very little pt cellulose, a woody, fibrous substance forming the cell walls. n burned, the ash of bran is found to contain a fairly large pro- ion of phosphoric acid, potash, and small amounts of other mineral ers. The cereal layer is, of all parts of the grain, the richest in genous substances, the chief of which is the cerealin from which it s its name. The endosperm contains, besides the cellulose of its walls, large quantities of starch, a little sugar, and a nitrogenous tance known as gluten. The germ contains cellulose, nitrogenous

substances, sugar, and a very large proportion—9 to 12 pe
of fat.

Grain, being hygroscopic—that is, having the power of a
water from the atmosphere—varies with the weather in the an
moisture which it contains; similarly, wheat grown in a wet s
a humid climate holds a larger percentage of moisture than t
kind grown under drier conditions. Thus English wheat conta
4 per cent more water than American. From comparison o
analyses, the average weight of the water in the grain is foun
about 12 or 13 per cent of its total weight.

Different kinds of wheat also vary as to the amount and qu
gluten which they contain. As gluten is one of the most
tant constituents of the wheat, the baker should know the chan
the gluten in the flour he uses. The so-called "hard" wheats a
in gluten of a strong, tenacious character, while "soft" wheats
less gluten and proportionately more starch. The gluten of har
can be mixed with large amounts of water, and produces a lar
from a comparatively small quantity of flour. Soft wheat,
other hand, while it does not yield so large a loaf, makes a bre
taining less water, and having a milder and more agreeable fla

It is useful for those interested in milling to know what
the grain will be most valuable in yielding a nutritious flour
of making a white, well-raised loaf. In considering the n
value of flour let us remember the principal kinds of nutrient
the body needs: (1) The nitrogenous substances, called prote
pounds or proteids, typified by the white of egg and the lean
and chiefly represented in wheat by the cerealin and the gluten
are the tissue-building materials of our food, though they also
energy; (2) the carbohydrates, principally starch and sugars
mainly in the endosperm, and serving the body as fuel to
energy for warmth and muscular work; (3) the fats, occurring
pally in the germ of the grain, and being valuable to the body
and (4) mineral matters, seen in the ash, especially that of th
and providing material for bones, teeth, etc. We must al
in mind that it is not only the chemical composition of a su
which determines its food value, but also the amount of nouri
which the digestive organs can extract from it—in other wo
digestibility.

The abundant cellulose in the bran and the coloring matter
testa tend, if left in the flour, to give it a coarse, dark ch
very detrimental to the appearance of the bread. Accordingl
recently, that flour was quite generally considered the best wh
the least of the bran in it. Lately, however, much stress has b
on the nutritive value of the mineral matters and the cerealin
bran, consequently a great effort has been made to get a fine flou

l include the entire wheat grain. Such flour can not produce as
te a loaf, and, what is still more to the point, it is doubtful whether
cerealin is thoroughly digested by the human stomach; moreover,
sharp, rough particles of the cellulose in the bran are said to irri-
the membranes of the alimentary canal and thus to hasten the
age of the food through the intestines. This would tend to dimin-
its digestibility, although it might be advantageous in counteracting
ndency to constipation. It would seem, then, that the value of
n in flour, unless it can be ground more finely than at present, is at
questionable. The germ, though rich in fat and ash, is also of
btful value in the flour, as it tends to darken the color, and its fat
sionally grows rancid and spoils the taste.

e endosperm is by far the most important contributor to the flour.
s starch lies the chief nutritive ingredient of bread. The gluten,
e principal nitrogenous constituent of wheat is called, is equally
ssary; mixed with water it forms a tenacious, elastic body which
nds under the pressure of the gas from the yeast until the dough
ll of gas-filled holes whose walls of tough gluten do not allow the
o escape, and thus make the dough light and porous. The more
en a flour holds, the more water it can be made to take up in dough,
the greater will be the yield in bread from a given amount of flour.
ce flours are classified as "strong" or "weak" according to the
portion of gluten which they contain and their consequent ability to
ld bread. Gluten has also a high nutritive value as an easily
ested proteid.

**illing.**—When people first began to grind their grain, they did so
ply by crushing it between any two stones which happened to be
dy; a little later they kept two flat ones especially for the purpose,
of which they soon learned to keep stationary while the other was
ned about on it. At first each woman ground the meal for her own
ily on her own stone; but after treadmills, windmills, and, later,
er wheels came into use all the grinding was done by the profes-
al miller in the village mill. In feudal days the lord forced his
ants to have their grain ground in his mill, even to bake their bread
is oven, and charged a good round toll for the use of each. Vari-
devices for grinding and sifting the grain have gradually been
nted, until to-day we have mills covering acres of ground and
g apparently impossible things with the grain. In Hungary the
Roman system of cylinder milling, similar in principle to an ordi-
coffee mill, has been developed, but elsewhere the systems which
known as high and low milling are more common. Here we have
original system of crushing between two stones, or rollers, but so
orated as to be almost unrecognizable. In low milling the grain is
nd in one process between two crushers placed as near together
possible. Graham flour and that commonly known as "entire-

wheat flour" are prepared in this way. Of these only the f
invented by the American physician, Dr. Sylvester Graham,
contains the entire grain; it is made by simply washing and cl
the grain and then grinding it between two stones or rollers,
surfaces are so cut as to insure a complete crushing of the
Entire-wheat flour is made in much the same way, except that
being washed the grains are run through a machine which re
the three outer layers, and then are ground. In this way the su
edly valuable cerealin layer is included without the almost a
cellulose of the outer bran. In high roller milling the grain is w
and skinned as in milling entire wheat, and then is run through f
even more pairs of rollers, each successive pair being set a little n
together than the last. After each grinding, or "break," as the n
terms it, the meal is sifted, and the leavings of each sifting, o
"tailings," are themselves ground and sifted several times. In a
where the grain goes through a series of six straight breaks,
are as many as eighty direct milling products, varying in quality
the finest white flour to pure ground bran. Careful millers al
try to grind as near the cerealin layer as possible, and to leave as
of the germ in the flour as is consistent with a good color. To
sure that each product is up to the standard set up for it in the
samples of it are tested every hour and the milling is regu
accordingly.

The so-called "straight-grade" flours ordinarily seen on the m
consist of the siftings of all the breaks plus the first product o
first tailings. "Patent" and "baker's," or "household," flour
varieties of the straight-grade flours. The accompanying tables
the chemical composition of various milling products and Am
wheat flours:

*Analyses of wheat and the products of roller milling.*[1]

| | Water. | Protein. | Fat. | Carbohydrates. | |
|---|---|---|---|---|---|
| | | | | Starch, etc. | Crude fiber. |
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Wheat as it enters the mill | 9.66 | 14.18 | 2.61 | 69.94 | 1.79 |
| First break | 8.23 | 14.18 | 2.68 | 71.56 | 1.62 |
| Sixth break | 7.66 | 16.28 | 5.34 | 59.42 | 5.60 |
| Bran | 10.91 | 16.28 | 5.03 | 56.21 | [illegible] |
| Tailings from reduction No. 5 | 12.12 | 16.63 | 3.85 | 63.93 | 1.19 |
| Second germ | 8.75 | 33.25 | 15.61 | 35.19 | 1.75 |
| Entire-wheat flour | 11.4 | 13.8 | 1.9 | 71.0 | .9 |
| Graham flour | 11.3 | 13.3 | 2.2 | 70.5 | .6 |
| Patent roller-process flour: | | | | | |
| Bakers' grade | 11.9 | 13.3 | 1.5 | 72.0 | .2 |
| Family and straight grade | 12.8 | 10.8 | 1.1 | 74.6 | .2 |
| High grade | 12.4 | 11.2 | 1.0 | 74.7 | .2 |
| Low grade | 12.0 | 14.0 | 1.9 | 70.4 | .5 |

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[1] U. S. Dept. Agr., Division of Chemistry Bul. 13, pp. 1226-1228, and Office of Experiment
Bul. 28 (rev. ed.), pp. 57, 58.

If, as often happens, it is desirable to blend two kinds of whe
order to obtain a flour with the average of their qualities, the g

usually mixed before milling. Sometimes the miller, or even the er, mixes two pure flours, but such a proceeding is less reliable.

ery complicated chemical tests are necessary to determine the exact lity of a flour, but there are certain general rules by which a good ad flour may be judged offhand. Its color should be white with a t yellow tinge; after being pressed in the hand it should fall loosely rt; if it stays in lumps it has too much moisture in it; when rubbed ween the fingers it should not feel too smooth and powdery, but its vidual particles should be vaguely distinguishable; when put veen the teeth it should "crunch" a little; its taste should be sweet nutty without a suspicion of acidity.

**mpurities and falsifications of wheat flour.**—The impurities which accidentally slip into a bag of grain, or even into the flour made n it, consist chiefly of the seeds of other plants, and of blighted olded wheat. The foreign seeds most to be dreaded are perhaps les and darnel, and both should be carefully guarded against—les because they injure the color of flour and bread, and darnel use it is commonly regarded as poisonous. Other foreign seeds not be equally dangerous, but they should be removed with equal , as they lessen the nutritive value and the strength of the flour. ds and other fungus growths often give a musty odor and taste to n or flour which has been kept in a damp place. Both these classes mpurities are easily avoided by careful milling and storing, and not so much to be feared as the foreign substances which are added he flour to cheapen its cost or improve its appearance. Those used heapen the cost are usually rye flour, corn (maize) flour, rice meal, ato starch, and meals from various leguminous plants, such as peas beans. They are not harmful in the food and sometimes improve color of the bread; nevertheless they are fraudulent because they er the quality of the flour without harming its appearance. The ture is sold as flour, and thus the purchaser secures an adulterated cle under a false name, and often at the same price as pure goods. eral substances, such as alum, borax, chalk, carbonate of magnesia, e, etc., are occasionally put into the flour to whiten it or to neutral- its acidity, but as these are more often used by the baker than by miller, their effect will be discussed later (p. 31).

## RYE.

he grain of rye is darker in color than that of wheat, but is other- similar in appearance. It differs, however, in one important icular—its gluten has not the same elastic, tenacious quality and not yield so light and well-raised a loaf. Although this fact and ark color make it less desirable than wheat flour, it is second in ortance as a breadstuff. It is more easily cultivated than wheat, cially in cold countries, and consequently costs less. In many s of Europe it practically replaces wheat among the poor and in the rations furnished the army. When it is milled entire, as is, it contains more protein than wheat flour, but is probably pletely digested. Wheat and rye flour are often used to bread.

### BARLEY AND OATS.

These cereals are so seldom used in bread that a short descr them will suffice. In general structure their grains are no those of wheat; in barley the proportion of the bran to th grain is about 21 to 79, in oats 44 to 66; the percentage of mo them is much lower than in wheat; their gluten is even less t than that of rye; though flours made from them without bran a high proportion of nutritive ingredients, they also contain amount of indigestible cellulose and are quite unsuited to yield attractive bread.

### CORN, OR MAIZE.

This cereal, commonly known to us as Indian corn, and on t tinent of Europe as maize, or Turkish wheat, is a native of A It is commonly grown in North and South America, northern India, and southern Europe, especially Italy and the Balkan and is slowly being introduced into other European countrie skin of the kernel is thin and tender, the endosperm abundant, and mealy, the germ comparatively large. See fig 2. The ker generally white or yellow. Compared with wheat, maize is ric poorer in cellulose and protein, an equal in carbohydrates, mineral and moisture. Most of its fat i embryo or germ, which is often r in milling to prevent the flour becoming rancid. Maize flour very nutritious and appetizing ened bread, hoecake, johnnycak but this dries so quickly that it eaten fresh. Maize flour cont tenacious gluten-like proteid, an fore can not be used alone to pr good loaf raised with yeast. Ma bread and other foods made fro meal are eaten in the United Sta Italy corn-meal mush, or "pole it is called, forms the principal of diet of the peasants in large throughout a considerable part year. In Servia the unripe corn is eaten much as we use it, a meal bread and mush are staple articles of diet.

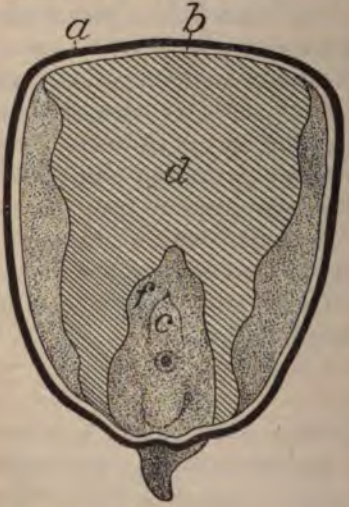

FIG. 2.—Section of grain of corn: *a*, skin and testa; *b*, membrane; *c*, embryo; *d*, endosperm· *f*, scutellum.

### RICE, MILLET, BUCKWHEAT, ETC.

Rice is a very important cereal in China, Japan, and other oriental countries; much millet is eaten in China, India, and Russia; sesame is also largely used by the native races of India, and in the United States buckwheat is often made into batter cakes; but none of these as a rule take the place of bread to any extent except in some oriental countries. In some regions of Russia, however, buckwheat porridge is the principal cereal food. Kafir corn is used in the United States to a limited extent for batter cakes, etc., though in its native land it is the principal cereal of large numbers of Abyssinians, Kafirs, and other races.

The following table gives figures by which the chemical composition of our most common cereals may be easily compared:

*Composition of cereals.*[1]

| | Water. | Protein. | Fat. | Carbohydrates. | | Ash. |
|---|---|---|---|---|---|---|
| | | | | Starch, etc. | Crude fiber. | |
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Barley | 10.9 | 12.4 | 1.8 | 69.8 | 2.7 | 2.4 |
| Buckwheat | 12.6 | 10.0 | 2.2 | 64.5 | 8.7 | 2.0 |
| Corn (maize) | 9.3 | 9.9 | 2.8 | 74.9 | 1.4 | 1.5 |
| Kafir corn | 16.8 | 6.6 | 3.8 | 69.5 | 1.1 | 2.2 |
| Oats | 11.0 | 11.8 | 5.0 | 59.7 | 9.5 | 3.0 |
| Rice | 12.4 | 7.4 | .4 | 79.2 | .2 | .4 |
| Rye | 11.6 | 10.6 | 1.7 | 72.0 | 1.7 | 1.9 |
| Wheat: | | | | | | |
| Spring varieties | 10.4 | 12.5 | 2.2 | 71.2 | 1 8 | 1.9 |
| Winter varieties | 10.5 | 11.8 | 2.1 | 72.0 | 1.8 | 1.8 |

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[1] U. S. Dept. Agr., Office of Experiment Stations Bul. 11, pp. 16, 17, and Bul. 28 (rev. ed.), p. 56.

## YEAST AND OTHER LEAVENING AGENCIES.

### THE THEORY OF FERMENTATION.

When, in beer making, a little yeast is put into a vat of warm, sweet liquid, bubbles gradually appear until the whole mass seems to be boiling. If the liquid is analyzed after the yeast has so worked in it for a time it will be found to contain less sugar than at first; the amount of yeast will have increased, and alcohol and carbon dioxid will appear in considerable quantities. The explanation is this: The yeast, which is really a mass of tiny plants, has reproduced again and again, and in this growth has fed upon the sugar of the liquid and given off alcohol and carbon dioxid. Such a phenomenon is called alcoholic fermentation, and is essentially the same as that which "raises" a loaf of bread. Such fermentation is by no means the only kind which occurs in common life. The souring of cider into vinegar, for instance, is due to another kind. In that case a variety of microscopic plant develops in the cider, and in so doing produces acetic acid, which gives vinegar its characteristic taste. This is called acetic f

Similarly, if another variety of bacteria get a chance t

sweet milk they give rise to lactic fermentation, during whic
duced the lactic acid which turns the milk sour. Rancidity
is due to the so-called butyric fermentation. Here the bacte
butyric acid, which gives the butter its disagreeable taste and

These microscopic plants and many others are widely distri
the air, and often find their way accidentally into different m
where they grow and multiply, causing fermentation, just
seeds, for instance, are blown about in the air until they lodge
favorable spot and grow. At other times special forms of fer
so-called "pure cultures" are purposely added to some mate
as seeds of larger plants are purposely sown in the garden
pure cultures of certain microscopic organisms are added
to improve the flavor of butter and make it uniform in quality
insures a special fermentation instead of the accidental ferm
which would otherwise occur. The term fermentation
applied to the action of yeast plants on sugar with the form
carbon dioxid and alcohol. There is another class of chemical
to which the term fermentation is applied. Such changes are p
by chemical substances called enzyms, which are not living or
but which are produced by living organisms. Ferments are t
divided into two classes, (1) the organized ferments, such
bacteria, etc., and (2) unorganized ferments, or enzyms. Hum
contains an enzym called ptyalin. When mixed with food in th
it changes starch into a form of sugar, which is more easily
than starch. In grain there exists an enzym called diastase, c
producing a similar effect on starch. The pepsin and trypsi
digestive juices are also enzyms.

It is a peculiar feature of fermentation that the microscopi
which cause it affect a much larger amount of the material
they feed than goes to their own development. Thus yeast
much more sugar into alcohol and carbon dioxid than it cons
its own growth and reproduction. When the fermentatio
the yeast plant remains; in other words, the fermentation
produced without changing the nature of the agent producing
the same way the enzyms cause fermentation without being the
changed. Though so much has been learned in recent years
ing fermentation, there still remain many things to be explaine
know what changes take place and under what conditions, but
they take place is not so clear. It is a remarkable fact co
ferments that the substances they produce, in time put a stop
activity. Thus the alcohol produced by the yeast in time is s
to hinder the growth of the yeast plant and ultimately to kill
however, the products of this activity are removed, the ferments
work.

Keeping the above facts in mind, it is easy to understand the leavening effect of yeast in dough. The yeast, "working" in the warm water and flour, feeds on sugar[1] originally present or else produced from the starch by diastase, grows and spreads throughout the dough, at the same time giving off carbon dioxid gas, which forces its way between the tenacious particles of gluten and lightens the dough.

Scientifically speaking, yeast is a minute fungus of the genus Saccharomyces. A single plant is a round or oval one-celled, microscopic body (fig. 3), which reproduces in two ways—either by sending out buds which break off as new plants, or by forming spores which will grow into new plants under favorable conditions. It grows only in the presence of moisture, heat, and nutritive material. If the moisture is not abundant the surrounding substances absorb that which already exists in the yeast cells and so prevent them from performing their functions. Yeast develops best at a temperature of 77°–95° F. (25°–35° C.). We have already seen how yeast uses up sugar in its growth. It is also believed that some nitrogen is necessary for the best development of yeast and that such development is most complete in the presence of free oxygen, but why these things are so is not yet clearly understood.

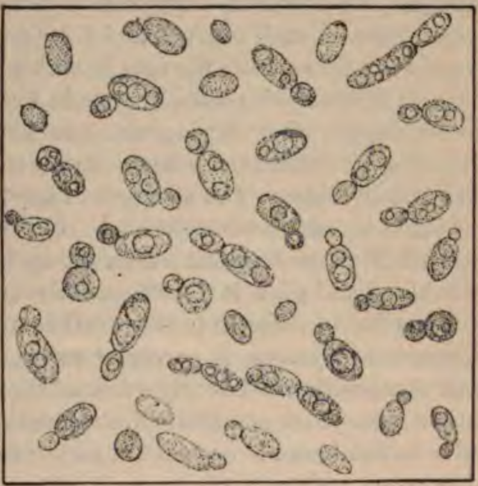

FIG. 3.—Yeast plant highly magnified.

Yeast is literally as old as the hills. It must be present in the atmosphere, for if a dish of malt extract, originally free from yeast, be exposed to the air, alcoholic fermentation, such as could be produced only by yeast, will soon set in. Such yeast is known as "wild yeast" and all our yeasts have been cultivated from it. The oldest method of growing yeast is perhaps that used by the Egyptians. A little wild yeast was obtained and set in dough, a portion of which was

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[1] The sugar upon which yeast is said to feed in its growth is not necessarily such sugar as we ordinarily use to sweeten our food. The word sugar is here used in its broader, scientific sense. All starches and sugars, it will be remembered, are grouped together by chemists under the name of carbohydrates. They are chemical compounds of carbon, oxygen, and hydrogen and differ from each other in the proportion of oxygen and hydrogen to carbon which they contain. For a more extended discussion of sugar see U. S. Dept. Agr., Farmers' Bul. 93.

old, found in Egypt, with other remains of a long
was made of ground barley and the yeast cells
A similar process of raising bread with "leaven
some regions of Europe. The "wet" or "potato
this country before the days of patent yeast,
method. Wild yeast was cultivated in a decoct
and water and some of the material thus obtaine
dough. The "barms" so much used in Scotlan
yeast grow in malt extract and flour (p. 22). B
yeasts are taken from the vats in which malt extr
ing. Compressed yeasts are made by growing
sweet liquid, then drying the material to che
pressing it; sometimes a little starch is added to
keep their shape. The strength of any yeast dep
which it is made and preserved. Ordinary bre
to be full of the bacteria which set up lactic or
the bread and give it a disagreeable taste and
susceptible to changes in the weather and can no
Compressed yeasts, if carefully made, are more
and composition. Usually a few of the microsco
other than yeast are allowed to remain, as the
give to the bread is considered an advantage.

### SUBSTITUTES FOR YEAST.

Partly because yeast is uncertain in its w
because it uses up some of the nutritive ingredi
feeding upon them, attempts have been made to fi
it. Various chemicals have been used to produce

merous baking powders made from various chemicals are in the rket now. The self-raising flour used in the United States Army flour ready mixed with such a preparation. The chief objections uch yeast substitutes are that unless carefully prepared they may inefficient or harmful, that they are easily adulterated, and that ad made from them is usually rather tasteless, lacking the flavor and ma which good yeast imparts. Soda, cream of tartar, or saleratus uits are made on the same principle, but with less powerful leaven- agents.

he "aërated bread" so popular in London is made by a different hod, invented by the English physician Dauglish in 1856. Accord- to this method, the water used for wetting the dough is directly rged with the requisite amount of carbon dioxid gas and then ed with the flour in a specially constructed machine. Sometimes ttle fermented barley infusion or wort, as it is called, from a very, is put into the water. This aids it in absorbing the gas, ders the gluten more elastic, and improves the flavor of the bread.

he so-called "salt-rising" bread is interesting as an illustration of raised bread. In it the ferments originally present or acquired the air produce the fermentation which leavens it. To make it, n milk and corn meal are mixed together into a stiff batter, which t at blood heat until the whole mass is sour; that is, until the fer- ts present have produced fermentation throughout. Next a thick ge is made of wheat flour and hot water, in which a little salt has dissolved. This sponge and the sour batter are thoroughly ded together and set in a warm place for several hours. The ning action started in the batter spreads through the dough and duces a light, porous loaf, which many persons consider very table. Such bread is quite free from acidity, as the presence of salt prevents undesirable fermentation.

## RAISED BREAD.

rdinarily a baker mixes his dough with water, and most of the eriments and analyses quoted here have been made with such bread. etimes, especially in private families, milk is used in the place of er. Such dough is slower in rising, but makes an equally light . Milk bread naturally contains a larger percentage of proteids fats than water bread and is equally digestible. Its use is by all ns to be advocated, especially on farms where skim milk is abun- t.[1] When water is used it should, of course, be as pure as possible. hardness or softness makes little difference in the quality of the d, though perhaps the softer water is to be preferred. Salt is used read because it imparts a flavor without which bread is usually

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[1] See articles on the digestibility of bread in Maine Sta. Rpt. 1898.

rules apply to them all. As yeast develops best
temperature (77°–95° F.), the materials of the do
lukewarm, and the mixing and the raising shoul
place, as free as possible from drafts. If all port
to be equally aërated by the gas from the growing
be thoroughly mixed with the flour and water; m
ence of oxygen aids the growth of the yeast, al
should be exposed to the air; both these resul
by the kneading. Too little yeast will, of course
loaf, but too much yeast is just as dangerous; th
the gluten of the flour, unable to resist the pressu
amount of gas, break open, the gas escapes, and
heavy and soggy. Too much yeast also gives an u
taste to the bread, due partly to the presence
cells, but more especially to other microscopic gr
mentations. Even when used in small quantities
influence on the flavor of the bread. The am
should be used depends on the strength of the flo
the gluten is abundant and tenacious can resist a
sure of gas than one poor in gluten, which, if it d
is likely to make a loaf with large holes and heavy
between. Similarly, the proportion of water w
varies with the strength of the flour. The stan
gest an average of about three parts of flour t
ratios changing with the quality of the flour. In
practical experience with his materials can teac
quantities which he should mix. Salt, as has been
fermentation, and consequently should be added t
mixing; then it is useful because it checks lactic o

the modern kneading machines, in which revolving metal blades do the work of the hands, are surely to be advocated, and in general those breads are to be recommended which are made with the aid of machinery so arranged that none of the materials need be touched by hand from the time they enter the bakery until the finished loaves are taken from the oven. Every utensil used for bread making should be scrupulously clean, not only on principles of general decency, but because otherwise bacteria may get into the dough and produce harmful fermentation.

The ways of mixing dough most used in this country by bakers are probably those known as "straight dough" and "sponge dough."

**Straight dough**, or "offhand" dough, as it is sometimes called, is made by mixing all the materials at one time, and then setting the mass in a warm place to rise for ten hours or more before baking. It requires more yeast and stronger flour than other methods in which the yeast is allowed to grow in an especially favorable medium before being mixed with the main dough, and needs a longer time to rise, but on the other hand gives an unusually large yield in bread. It is convenient in family bread making, especially when strong, compressed yeast is used, as the dough can be mixed overnight and baked in the morning. Some wholesale bakers dislike it because the dough is stiff and hard to knead, because the large quantities of materials used at one time require extensive kneading apparatus, and because the bread is usually coarse in texture, with a raw, grainy taste, due to the strong flours used.

**Sponge dough.**—This method is best adapted to fancy working, and makes equally good crusty loaves or light biscuit. To make the "sponge," as the bread mixture is commonly called, the yeast is allowed to work for eight or ten hours in a portion of the flour or water. This is then mixed with the remaining materials and left to rise a few hours before baking. The sponge is "slacker"—that is, contains more moisture than offhand dough—and thus gives the yeast a better chance to work. Bakers usually set their sponge with a strong flour, which gives a light, elastic quality; a little salt is put into it to prevent lactic fermentation. A weaker flour may be used in the second mixing, as the greater part of the gas has already been given off in the sponge, and no great pressure will come on the newly added gluten. If strong flour be used instead, the bread yield will be greater, but the soft, sweet flavor imparted by the weaker kinds will be replaced by the harsh taste noticed in bread made from offhand doughs. Great care must be taken to mix the second lot of flour in thoroughly, or the bread will be full of hard lumps on which the yeast has had no effect. Sponge-made bread usually rises evenly and well, and can be worked into almost any shape. It has the further advantage of ke
requires longer labor than the method described bef

of dough. If the gas is allowed to go on increas
is greater than the elasticity of the gluten can re
apart, leaving large holes throughout the dou
proved" dough is kneaded a little before it is p
excessive gas will be forced out and the holes wil

Besides the methods of bread making noted a
occasionally used. Jago[1] describes those emp
England and Scotland. The following stateme
description:

**Ferment, sponge, and dough method.**—As the n
combination of the two methods last described.
with the sponge, then, after this has stood for se
of the flour and water are mixed in the sponge
There is, perhaps, a slight economy of yeast by
very complicated, and therefore less certain.

A similar proceeding is sometimes practiced in
the United States, and is known as a "bleaching
long rising is supposed to whiten the dough.

**Scotch barm method.**—This is not unlike the
dough system, "barm" taking the place of the ot
is literally the foamy scum which rises to the to
made. This may be used to ferment other mat
yeast is also called barm. To make barm in th
crushed in warm water, hops and boiling water ar
flour is added, and the mixture is allowed to st
granules from the flour have been burst open
the starch thus freed has been changed into sug
the malt. A sweet liquid is drained off from this
and water, the resulting sticky mass being subj

into the bread. These arguments seem hardly tenable, however. The cost of labor in preparing the barm must be considerable and at least a portion of the flour in the barm is lost in the form of alcohol and carbon dioxid. Moreover, while the barm is exposed to the air in making it takes in a great many bacteria which start lactic and other fermentations and give a decidedly sour taste to the bread. To be sure, persons accustomed to such bread find an ordinary sweet loaf insipid. Still such a flavor would, it is probable, hardly be acceptable to the average American palate.

### BREAD MADE WITH LEAVEN.

According to Boutroux,[1] the leaven used in France is easily prepared. A little of the dough ready for baking is saved and mixed with an equal amount of flour and water and is allowed to stand four or five hours; this operation is repeated three or four times before the leaven is ready to be mixed into the actual dough. This gradual mixing of the leaven is preferred, because in this way the yeast is allowed to act on one lot of flour only for a short time, then before it has become exhausted and other fermentations set in new yeast food is added, and thus a large number of yeast cells is supposed to be produced along with relatively few lactic and butyric bacteria. In spite of this precaution, bread made with leaven has a much more acid taste than that made with yeast, especially if the leaven has been kept some time. Anyone who has eaten the bread ordinarily made by the poor country people of France or Switzerland will willingly testify to this. More leaven is required in winter than in summer, because the yeast develops less quickly in cold weather, but on the average the leaven should form one-third of the entire dough. Bread made with leaven has large, irregular holes in its crumb. This is attributed to the fact that the bacteria in the leaven give rise to a ferment (diastase) and acids, which tend to soften the gluten.

Boutroux considers bread made with leaven more healthful than that made with yeast, because the acids it contains aid in its digestion. He also maintains that leaven is more reliable than the yeasts ordinarily found in the French market, but probably the majority of experts in this country would hold that the best of our compressed yeasts are more reliable and much more convenient. Whatever its practical value nowadays, bread made from leaven is interesting from the historical point of view, as it represents the way in which almost all the world made its bread from the time of the Pharaohs down to our own century. The following description[2] of bread making, as practiced by

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[1] Le Pain et la panification. L. Boutroux, Paris, 1897.

[2] The Dawn of Civilization. Egypt and Chaldæa. G. Maspero
Prom. Christian Knowledge, 1897, 3 ed., p. 320.

mixed with bran or whole grains which had escaped the
with dust and abraded particles of the stone. She knea
blended with it, as a sort of yeast, a piece of stale dough of
from the mass round cakes about half an inch thick and
eter, which she placed upon a flat flint, covering them wit
imperfectly raised, often badly cooked, borrowed from the
it was buried a special odor and a taste * * *.

## SPECIAL BREADS.

Besides the ordinary white bread described in t
are innumerable fancy white breads, breads ma
than wheat, and unleavened breads on the mark
of them have been made, however, that they can
enumerated here.

### FANCY LEAVENED BREADS

Most like the ordinary white bread are of co
ones, Vienna and French rolls, milk breads, etc.
chiefly in the use of milk, sugar, butter, lard,
Entire wheat, graham, rye, barley, or oatmeal f
bread in essentially the same way, and vary in te
value according to their original composition. S
or baking powder biscuits, shortcakes, etc., are i
thing as ordinary white bread, except that the b
substitute does the work of yeast. Such breads
kneaded or set to rise, and bake very quickly,
venient when yeast is unobtainable or time is
become so light and porous as yeast-made brea

varieties, of unleavened breads. Milk, butter, lard, spices, dried fruits—anything or everything desired to give them a particular consistency, color, or flavor—is mixed with the flour and water, and the dough is then passed through very ingenious cutting machines and quickly baked in a hot oven. Such crackers are a concentrated form of nourishment.

The original graham bread made without yeast from graham flour according to the receipt of its inventor, and not to be confounded with raised graham bread, is made by kneading the flour and water thoroughly, and allowing the dough to stand several hours before baking. It is heavier than ordinary yeast bread, but still has a few "holes" in it, due probably to fermentation started by bacteria accidentally present in the flour or the air; it is sweet and by no means unpalatable, but probably the nutritive value of its protein is lower than Dr. Graham supposed.

Gluten bread, as its name implies, contains the gluten of the flour from which more or less of the starch has been removed. To make it, strong flour and water are made into dough, which is pressed and strained under a stream of water until the starch has been worked out; it is then kneaded again and baked. It makes a light, elastic loaf, frequently prescribed for diabetic patients from whose diet it is considered desirable to exclude starch.

## HOUSEHOLD METHODS OF BREAD MAKING.

In preceding paragraphs attention has been called to the methods of bread making followed by bakers. These differ from the household methods more in the quantities used than in the principles followed. Thus, a baker uses a large amount of flour and finds that mixing the dough and kneading it is much facilitated by machinery of different sorts. With the small quantities used in the household special machines for kneading, etc., are not commonly used. In different regions somewhat different ways of making bread in the household are popular, and, indeed, each bread maker is apt to believe she has some especially valuable way of mixing, kneading, etc. These differences are not as important as is sometimes supposed, and, as has been said, the general principles followed in bread making at home are the same as in bakeries. What are perhaps the two most popular ways of making bread at home are sometimes called the "quick-raising" method and the "slow-raising" method.

**Quick-raising method.**—A stiff dough is made of the flour, water, and yeast. It is thoroughly kneaded and is then allowed to rise until it doubles its bulk, when it is again kneaded thoroughly. After rising a second time it is baked. In the quick-raising process
quantity of yeast is used, and the time of fermentation is
two and a half hours. The baking is completed in about
hours after the bread is first started to

**Slow-raising method.**—A batter is made of the flour, yeast, and water, which is allowed to ferment ten or fifteen hours, usually over night. More flour is then added, the dough is kneaded until smooth, and then allowed to rise and is treated in the same way as in the first method. In the slow-raising method less yeast is used than in the short process, and the fermentation is carried on for a longer time. The usual temperature at which the fermentation thus takes place is perhaps not far from 70°.

Various forms of "raised biscuits," "hot bread," etc., are made in the household by adding shortening, milk, eggs, etc., to the dough, or by modifying in some way the process followed. Sometimes baking powder of some sort is used as a leavening agent instead of yeast, and the form of bread called "baking-powder biscuit," or by some similar name, is the result. An interesting variety of bread made without leavening is known as "Maryland" or "beaten" biscuit. A rather stiff dough is made from flour and water, or milk, with shortening and salt added. It is kneaded and then beaten or pounded, being frequently turned over and over until it looks light and puffy. The biscuits are then formed and baked. The folding and pounding of the dough incloses small quantities of air in numberless little blisters. These expand in baking and make the biscuit light and porous. The different kinds of bread from other grains than wheat, as "corn bread," "brown bread," "rye bread," "gems," etc., which are made in many households vary somewhat in different regions, but they all follow the same principles which govern the bread making from wheat flour—that is, the flour or meal is mixed to a dough with water or milk, and some leavening substance is generally added to make the dough porous. Eggs, sugar, shortening, etc., may be added, giving rise to the numerous varieties with which we are all familiar.

## BAKING AND COOLING.

In the earliest days of bread making the dough was simply put into the ashes of the fire to bake; then came the ovens heated by a fire within, which are still used to some extent, and finally the elaborately constructed ovens which can be heated or cooled to any temperature by means of furnaces and ventilating devices around them. But whatever the structure of the oven, the changes which the bread undergoes while in it are essentially the same. It goes in a heavy, uniform mass and comes out a light body of increased volume with a crisp, dark exterior—the crust—and a firm, spongy interior—the crumb. Let us first see what happens in the crumb. This, of course, heats more slowly than the outside; indeed, the moisture which it contains prevents its temperature from rising much above the boiling point of water (212° F.). When first put into the oven the yeast continues working, but a temperature of 158° F. kills it. The gas in th h, however, still expands and, forcing its way outward, enlarges oaf and gives it a spongy appearance. The gluten becomes stiff- by the heat, so that even after the gas in the bubble-like pores scaped the walls still retain their shape. The starch granules and ps the protein compounds undergo certain chemical changes which r them more digestible. Meanwhile the crust is becoming hard ark; the heat changes its starch into stiff gum and sugar and dries e moisture; the brown color is due to chemical changes known as amelization.” Of course the proportion of crust to crumb varies the size of the loaf. The accompanying table[1] gives the relative ntages by weight in loaves of different weight of German bread:

*Comparative weight of crust and crumb in bread.*

| | Weight of loaf. | Crumb in loaf. | Crust in loaf. |
|---|---|---|---|
| | *Grams.* | *Per cent.* | *Per cent.* |
| No. 1 | 398 | 55.2 | 44.8 |
| No. 2 | 880 | 59.7 | 40.3 |
| No. 3 | 1,783 | 64.3 | 35.7 |
| No. 4 | 1,998 | 71.2 | 28.8 |

e heat in the oven should not be too great, especially at first, or utside of the bread will harden too quickly and the interior will be done before the crust is thick and dark; further, the gas nding in the crumb will be unable to escape through the crust will lift up the latter, leaving great holes beneath it. To prevent rapid formation of the crust bakers often moisten the tops of their es before putting them into the oven, or have devices for passing m over them during the baking. The steam also changes some of starch into a sort of gum on the top of the loaf and gives it the y look so often seen in Vienna bread. The same effect can be duced by moistening the top of the loaf just before it is taken from oven. If his oven is not equally heated throughout, a baker ally puts his small loaves into the hottest part at first, as the crumb hese bakes more quickly and is in less danger of being underdone. en these are baked the larger loaves, whose crumb has baked grad- y in the cooler parts, are moved into the warmer place and their st is quickly hardened. In some large ovens the temperature is dually raised during the baking; especially is this the case in the ted bread factories. Aërated dough is mixed with cold water, if it were immediately subjected to a high temperature the crust ld form before the interior was more than warmed through. ordingly, a peculiar oven is used, one end of which is heated much er than the other. Two cylinders, one at either end of the oven, connected by an endless chain, on which the bread plates are hung; dough is placed on the latter at the cooler end, and then is gradually swung over to the warmer end, the speed being regulate the time needed for baking. This insures a thorough baking o crumb, while the extreme heat at the last gives a good, crisp crus

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[1] Arranged from Birnbaum's Das Brotbacken. Braunschweig, 1878, p. 255.

The temperature of an oven and the time required for baking de upon the size of the loaves. Small biscuits or rolls can stand a hotter oven and quicker baking than large loaves, which mus heated slowly and long. For ordinary purposes a baker heats his to 400°–500° F. and lets a pound loaf bake an hour or an hour a quarter; small rolls perhaps half an hour. An experienced cook tell when the oven is hot enough by putting the hand in, but a py eter, as a thermometer for measuring high temperature is called, m a much safer guide for an ordinary person.

On being taken from the oven bread should be placed on slat sieves so that the air can circulate about it until it is thorou cooled. By that time all the gas and steam which are likely to es have done so, and the bread may be put away. Some housekeepers their hot bread in cloths, but this is not advisable, not only becau makes the bread "taste of the cloth," but also because it shuts steam up in the loaf and makes it damp and clammy—an exce medium for cultivating mold.

Of course, as great cleanliness should be observed in handling marketing bread as in making it. In some bakeries it is kept w the dust and dirt from the street can get to it, or sometimes bre delivered in dirty baskets or carts. In this way disease germs dirt may readily be brought into the home. In Germany th sometimes avoided by slipping the loaves into parchment-paper as soon as they are taken from the oven. Some American bakers similar plans; a frequent one is that of wrapping the bread in pa paper, which serves the double purpose of keeping out dirt and venting the bread from drying.

## CHEMICAL COMPOSITION.

The chemical composition of the finished loaf differs somewhat that of the original ingredients. The following table shows the ence in composition between flour and bread:

*Average composition of white bread and of the flour from which it was made*

| | Water. | Protein. | Fat. | Carbohydrates. |
|---|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Bread | 35.3 | 9.2 | 1.3 | 53.1 |
| Flour | 12.0 | 11.4 | 1.0 | 75.1 |

[1] U. S. Dept. Agr., Office of Experiment Stations Bul. 28 (rev. ed.).

The increase of water in the bread hardly needs explanation it is evidently due to the water added in making the dough. of butter or lard and salt probably accounts for the excess

The protein and carbohydrates lost doubtless went to nourish
yeast. Most of the carbon dioxid into which they were converted
sed out of the bread. According to Birnbaum[1] the baked bread
tains an average of 0.314 per cent of alcohol,[2] by no means all of
generated by the yeast (about 1 per cent, according to Snyder);
t is evaporated and part is probably changed into acetic acid. The
teria and other microscopic plants which accompanied the yeast
btless took their share of the protein and carbohydrates, returning
rt in the form of the characteristic acids and other bodies which
y produce. Part of the starch in the crust has been changed into
trin, and that in the crumb has become gelatinous or partly soluble.
gluten, as we have seen, has taken definite shape. This really
ns that it has coagulated very much as the white of an egg does in
ing.

## STALE BREAD.

ood fresh bread has a crisp crust which breaks with a snap, and an
tic crumb which springs back into shape after being pressed with
finger. Before bread is a day old, however, its texture has changed;
rust has become softer and tougher, while the inside seems dry and
mbly, the bread is "growing stale," as we say. This was formerly
posed to be due simply to the drying of the bread, but as the loss
water is found by experiment to be comparatively slight, some other
lanation is necessary. Various explanations have been offered, of
ch the most interesting seems that given by Boutroux in the work
ady quoted. He maintains that the apparent dryness is due to a
fting of the moisture from the crumb to the crust. When first taken
n the oven the dry crust cools quickly, but the moist crumb retains
heat much longer. As gradually, however, its temperature falls to
t of the surrounding atmosphere, its moisture tends to distill out-
rd, leaving a comparatively dry crumb and moist crust. Common
perience shows that if stale bread is put into the oven for a few
nutes it regains something of its fresh consistency—a crisp crust
d moist crumb. This fact would be explained by the reverse of
ofessor Boutroux's proposition; that is, the moisture is driven back
to the crumb. Such warmed-over bread lacks the elasticity of the
esh loaf, and its interior crumbles as easily as before it was reheated.
is is supposed to be because the starch has undergone a chemical
ange, the nature of which is not yet clearly understood. Indeed,
whole question of staleness is one about which little has been abso-
ely proved.

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Das Brotbacken. Braunschweig, 1878, p. 252.

On the other hand, Snyder found that no appreciable amount of alcohol remained
breads after baking. (*U. S. Dept. Agr.,* Office of Experiment Stations Bul. 67,
5.)

## IMPERFECTIONS AND IMPURITIES IN BREAD.

One of the most common and dangerous faults in bread is he
and sogginess. As we have seen, this may be caused by the
cheap flours, poor in gluten, which can not absorb all the wat
into the dough, or, to state it in another way, by the use of to
water in proportion to the flour; by too little or by too poor
or by insufficient kneading, rising, or baking. Heavy bread is
larly considered one of the most indigestible of foods. When
it rolls itself into solid lumps, which give the saliva and gastric
very little chance to work upon them.

Occasionally the crumb of fresh bread breaks when cut, ins
separating cleanly under the knife. According to Jago,[1] har
flours, not sufficiently fermented, may be the cause of this,
dough may have lost its tenacity by being overworked.

Another common fault in bread, especially in baker's brea
crumb full of large, irregular holes instead of the small, even
which it should show. These occur in overkneaded or over
dough, or if they are found just below the crust they mean th
oven was too hot and that the crust formed before the carbon
had finished expanding.

Sometimes bread makers are troubled by what is known as "st
or "slimy" bread. In such cases bread three or four days old
on a light-brown color and a peculiar taste and odor. Graduall
it becomes sticky or slimy until it may be pulled into strings,
times several feet in length. The trouble appears to be caused
common potato bacillus (*Bacillus mesentericus vulgatus*), a minute
ism which finds its way into the materials of the dough, surviv
baking, and, growing in the bread, causes it to decompose. E
ments recently made at the Wisconsin Experiment Station[2] sho
the bacilli enter the bread with the yeast, which in the cases i
gated was a variety of the compressed yeasts ordinarily on the
It was also proved that the bacilli will survive the heat of bakin
cordingly, if yeasts are not carefully made such trouble may
any time, but especially when the weather is warm and favo
the growth of the bacilli. The best safeguards are to keep th
in a cool place and to bake only as much as can be consumed
day or two.

Not infrequently, especially in damp weather, mold forms
outside, or even in the inside of bread. Mold, like yeast, is
plant whose spores (or seeds) are floating about everywhere in
ready to settle down and grow wherever they find a moist,
home for themselves. The best practical way to protect bre
them is to keep it in a dry, air-tight box.

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[1] The Science and Art of Breadmaking, by William Jago, London.

[2] Wisconsin Sta. Rpt. 1898, p. 110.

But all these faults seem insignificant compared to that dread of bakers, sour bread. This is due to lactic, or, in the worst cases, tyric, acid given off by undesirable bacteria in their growth. A le acid is not necessarily harmful, as was seen in the discussion of ead made with leaven and barm; but when the acidity is very pro- unced or even accompanied by putrefaction (developed in company h butyric acid) then something is radically wrong. Possibly the ssels in which the bread was made were not thoroughly cleaned after last using and some of the undesirable bacteria got into the dough m them; or perhaps the yeast contained an undue proportion of se bacteria; or, if the latter were found only in normal quantities, ssibly the yeast itself was weak and was quickly exhausted. The uble may be due to the fact that the dough was allowed to stand long after mixing, the yeast ceased working, and the dangerous teria which grow best in the presence of acetic acid, such as occurs er alcoholic fermentation has ceased, had gotten the upper hand. none of these things are at fault, the undesirable bacteria may have ne from the flour itself. Such cases are fortunately very rare, and baker guards against all the other dangers, he is pretty sure to make eet bread. If bread grows sour with age it has probably caught undesirable bacteria from the air, just as it catches mold. Very ely, however, bread perfectly sweet at first grows sour before the teria in the air have had a chance to get at it. The only possible lanation for this is that the bacteria have managed to survive the ing and are growing luxuriantly in undisputed possession of the d things in the bread.

Besides these acid-producing bacteria, various others occur in bread, stly harmless, but some of them very curious in their effects. Most king among these is the *Micrococcus prodigiosus*, a minute organism ich makes blood-red spots in the dough and whose presence gave e to many interesting superstitions during the Middle Ages.

Aside from the adulterants mentioned in the section on flour, those st commonly met with in bread are mineral salts mixed into the dough the purpose of producing a good-looking loaf from poor flour. um is the most common of these. It tends to check the action of the stase and permits a weak flour to absorb more water than usual. It o improves the color of the bread. Many reliable bakers use it under impression that it does good and not harm; but besides producing read whose nutritive value is not so great as appearances indicate, s believed to be really injurious to the digestive system, and must ranked as an objectionable adulterant. Alum tests are usually made soaking a sample of the suspected bread in a solution of tincture of wood and ammonium carbonate, in which alum betrays itself by a ish color. Copper sulphate is used to produce an effect similar to t of alum in bread, but is believed to be more dangerous. Lime rts practically the same influence and does no particular harm

se is reprehensible only because it gives poor bread the appea
f good bread.

Soda is often used in bread to prevent souring, and as it doe
ssen the value can hardly be called an adulterant. In breads
rom special flours poor in gluten—oatmeal, barley, etc.—soda is n
ary in the production of a sweet, well-raised loaf.

## NUTRITIVE VALUE AND COST OF BREAD.

### COMPARISON OF THE COMPOSITION OF BREADS AND OTH FOODS.

If we wish to know which of several foods furnishes the most a
ourishment for the least cost, we must know not only the actual p
nd the nutritive ingredients of each, but also their relative dig
ility, and the one which is found to furnish the greatest amou
igestible nutrients for a given sum will be the cheapest.

To show the difference in the proportions of the different
ngredients in various foods, it may be well to compare the analys
read and other foods as given in the following table:

*Composition of various food materials.*[1]

| | Number of analyses. | Refuse. | Water. | Protein. | Fat. | Carbohydrates. |
|---|---|---|---|---|---|---|
| | | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* |
| orn bread (johnnycake) | 5 | ........... | 38.9 | 7.9 | 4.7 | 46.3 |
| ye bread | 21 | ........... | 35.7 | 9.0 | .6 | 53.2 |
| ye and wheat bread | 1 | ........... | 35.3 | 11.9 | .3 | 51.5 |
| heat bread, "gluten" | 6 | ........... | 38.2 | 9.3 | 1.4 | 49.8 |
| heat bread, "graham" | 27 | ........... | 35.7 | 8.9 | 1.8 | 52.1 |
| heat bread, "rolls" | 20 | ........... | 29.2 | 8.9 | 4.1 | 56.7 |
| heat bread from high-grade patent flour | ........ | ........... | 32.9 | 8.7 | 1.4 | 56.5 |
| heat bread from regular patent | | | | | | |

From various dietary standards it is reckoned that the average man moderate work requires about 0.28 lb. of protein to 0.28 lb. of fat d 0.99 lb. of carbohydrates in his daily food, which together furnish 00 calories of energy. The harder he works the more food he need. Milk contains the three classes of nutrients, but not in proper proportion for adults in health. The large quantities of lk which a man would have to drink in order to obtain the necessary ount of nourishment make it inconvenient for exclusive use. Meats rich in protein. Vegetables are especially rich in carbohydrates. ead contains the three classes of nutrients in about the right proportion; still in order to get the requisite amount of protein from it one uld have to take more carbohydrates than is otherwise necessary. must not be supposed that it is impossible to live without the three sses of foods in the given proportion. The poor of India and China d other Eastern countries often live almost entirely on cereals, and ve become so accustomed to this diet that they refuse to change. ey, however, secure more protein than is ordinarily supposed by the e of sauces, vegetable cheese, etc., made from legumes, notably soy ans.[1]

Turning to the bread analyses, we see that wheat bread from lowade flour, wheat bread from bakers' flour, and rye-and-wheat bread ntain the largest amount of protein; corn bread and wheat rolls, the st fat; and wheat rolls, wheat bread from high-grade patent flour, d wheat bread from regular patent flour, the most carbohydrates. e amount of fat would, of course, vary greatly with the amount of ortening added in making the bread, and the examination of a large mber of analyses of the same kind of bread has shown that the ount of each of the several nutrients varies in the same sort of bread thin rather wide limits. Judged by their composition, all breads e nutritious foods, and too great stress should not be laid on the riations in composition between the different kinds.

## DIGESTIBILITY OF DIFFERENT KINDS OF BREAD.

The next question is, Which kind of bread furnishes the greatest nount of digestible nutrients? Unfortunately no experiments have en made with exactly the same materials as those represented in ese tables, but investigations conducted on similar lines will not be ithout value in this connection.

Among the best known of such experiments are those conducted by eyer and Voit, of Munich, about twenty-five years ago. Four kinds bread were used: (1) Rye bread, raised with a leavening powder; ) bread made from a mixture of rye and wheat flours and raised with ast; (3) fine white bread raised with yeast, and (4) coarse whole-wheat bread, which the Germans call "pumpernickel," raised with yeast. The third of these, fine white bread, yielded the highest percentage of digestible nutrients, next came the wheat and rye bread, then the bread raised with the leavening powder, and last the pumpernickel. The pumpernickel may be left out of account, as it was too coarse to be justly compared with whole-wheat bread such as is made in the United States. The fine white bread was the lightest of the other three, next to it stood the rye and wheat, and last that raised with the powder, the same order that they took with regard to digestibility. These experiments prove, not so much the comparative value of different flours, as that the digestibility of bread depends largely upon its lightness.

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[1] U. S. Dept. Agr., Farmers' Bul. 58, Appendix.

Recent investigations conducted at the Maine Experiment Station[1] throw light on the question of comparative value of various kinds of bread. Experiments were carried on with several subjects with the following results:

*Comparison of nutrients digested and energy utilized in different kinds of bread.*[1]

| Kind of food. | Number of experiments. | Nutrients digested. | | | Energy utilized. |
|---|---|---|---|---|---|
| | | Protein. | Fat. | Carbohydrates. | |
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| White bread alone | 4 | 82 | 70.7 | 98.4 | 92.1 |
| White bread with milk | 9 | 88.3 | 66.6 | 98.2 | 94.8 |
| Graham bread with milk | 6 | 77 | 58.1 | 92.4 | 89 |
| Entire-wheat bread with milk | 5 | 86.6 | 46.2 | 97.2 | 94 |

[1] Maine Sta. Rpt. 1898, p. 207.

The figures in the last column, marked "energy utilized," were found by burning (in a bomb calorimeter) the equivalent of the food consumed and measuring the heat given off thereby, and from this calculating the heat which the amount digested should furnish. Heat and the energy of muscular work, voluntary and involuntary, are but different manifestations of the same force; consequently, using the proper factors, we may approximately determine the value of any food as a source of energy by measuring its heat of combustion.

From this table we infer that white bread yields the highest percentage of digestible nutrients; next comes entire wheat and last graham bread. (It should be stated that the graham bread used here was not the unleavened variety, but was made with yeast.) As was to be expected the whole-wheat breads made from carefully prepared flours proved much more digestible than the cheap pumpernickel used in the German experiments. It is also worth noticing that the entire wheat flour prepared without the three outer layers of the grain makes a more digestible bread than the graham flour containing the whole grain.

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[1] Maine Sta. Rpt. 1898, p. 197.

Part of the experiments reported in this table were made with bread alone; the rest with bread and milk. This was because a man accustomed to a varied diet finds it impossible to digest or even to eat large quantities of bread alone. How much more nourishment he gains from the same amount of bread taken with milk may be seen by comparing the experiments with white bread alone with those with white bread and milk. In the Munich experiments the subject took beer and butter with his bread. In both cases the figures quoted were calculated to give the nutrients of the bread alone.

The amount of actual nourishment which a given weight of bread will furnish is found by multiplying the weights of its nutritive ingredients by their percentages of digestibility. Let us take the number of heat units or calories[1] which a gram of bread will give off when burned as the measure of its nutritive ingredients. From the tables given in the Maine Station Report these are found to average:

| | Calories per gram. |
|---|---|
| White bread | 2.83 |
| Graham bread | 2.55 |
| Entire-wheat bread | 2.65 |

Multiplying these by the percentage of energy utilized from each bread, we find that 1 gram of white bread eaten alone yielded 2.69 calories, eaten with milk, 2.78 calories; 1 gram of graham bread yielded 2.18 calories and 1 gram of entire-wheat bread 2.35 calories. From this point of view white bread is still the most advantageous. The chief argument for the entire wheat and graham flours is that they furnish larger amounts of protein, the kind of food in which bread is most lacking. Let us see what these Maine experiments say of this. From them we calculate that 1 gram of average white bread contains 0.086 gram of protein, graham bread 0.083 gram, and entire-wheat bread 0.086 gram. Multiplying these by the percentages of digestibility of protein, 1 gram of white bread with milk will furnish 0.076 gram of digestible protein, while the same weights of graham and entire-wheat bread will furnish, respectively, 0.064 and 0.074 gram. Thus we see that even in regard to the amount of protein digested, white bread is still the most valuable; next comes entire wheat and last graham bread.

As regards the claim that the bran-containing flours furnish valuable mineral matters and fats, it should be stated that as yet no experiments have been made to test the digestibility of these substances, and until that is done nothing positive can be said on either side. Too much stress should not be laid on the importance of the extra amount of phosphates and other ash constituents of bran. Fine flour also contains these same constituents and it is not unlikely that they are more

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[1] A calorie represents the amount of heat necessary to raise a kilogram of water 1° C., *or a pound of water 4° F.*

ailable than in the bran, even if finely ground. These su
e of undoubted value, but there is little experimental data
e amount of different ash constituents necessary for maintai
dy in health. It is doubtless safe to say that the ordinar
et of children and adults furnishes an abundance of mineral
ie coarser flours, with the particles of bran, often increase t
iltic action of the intestine and thus tend to prevent const
iey may at times otherwise aid digestion, hence for persons
a laxative, bread made from such flours may often be pr
white flour, but for a healthy person its claim of superio
very questionable. Certainly no plea can be made for them
ound of economy, for entire-wheat and graham flours cost m
iite flour.

The coarse flour used in the German bread called pump
sts less, but it is doubtful whether a cent's worth of it furn
uch nourishment as a cent's worth of white flour. The comp
gestibility of the various grades of white flour was recently i
ted in Minnesota[1] and it was found that the difference betw
aounts of digestible nutrients furnished by breads made from
ller process and bakers' flours was very slight. Unfort
ere are no statistics at hand from which to compute the comp
st of the digestible nutrients in rye, corn, and other brea
erman investigations recently made in reference to army bre
nclusions are drawn that if complete digestion of the nutri
e bread is the main object the cheaper grades of white flour
ost economical, but that if low cost is also an object, a mix
e and white flour is to be recommended.

Statements of a popular nature are frequently met with
iwholesomeness of hot bread. The fact that bread is hot has

.[1] tend to show that bakers in those sections set their prices by the e and trade name of the bread. Thus in New Brunswick, where fifty lyses were made, the bread containing the highest amount of nutri- s and that containing the lowest were sold at exactly the same price r pound, 4.1 cents. In New Jersey it appeared that the larger the f the higher the cost per pound tended to rise. The average cost bread seems to vary in different localities; thus, while the investi- tions just referred to were being carried on it averaged from 5 to cents a pound in Middletown, Conn., from 3.8 to 4.9 in different ies in New Jersey, and 3.75 in Pittsburg.

When the selling price of bread and the cost of its ingredients are mpared the results are still more striking. In two experiments ade in New Jersey it was found that two lots of bread made from aterials costing, respectively, $2.28 and $2.56 were sold for $5.86 and .08. This represents a profit of 116.5 per cent over the cost of the aterials, or, to put it in dollars and cents, the baker received $216.50 r bread whose materials cost him $100. In Pittsburg the average crease in price over the original cost was 110 per cent. Even sub- acting from this the cost of labor, rent, fuel, etc., the profits of the ker are so high that, to quote from the Pittsburg report, "It would em that in the case of very poor families * * * an important cuniary saving would result if bread was made at home. To the an in ordinary circumstances it must always be more a question of nvenience and taste than of cost. In short, each family can best termine for itself whether it is desirable to pay the baker for the ouble of making the bread and delivering it, or whether the labor of aking and the extra fuel for baking can best be provided at home."

## SUMMARY.

Cereals of some kind or other have always made an important item human food, and of all the forms in which they have been used read has proved the most satisfactory, because the most digestible d appetizing, To prepare the grain for bread making it is usually eansed, crushed, and sifted into a fine, soft powder which we call our. Among various flours the preference should of course be given the one which yields the most nutritious loaf for the least money.

The nutritive value of bread depends not only on its chemical com- osition, but also on its digestibility, and digestibility, in its turn, eems to depend largely on the lightness of the loaf. It is the gluten a flour which gives it the power of stretching and rising as the gas rom the yeast expands within it, and hence of making a light loaf. ye, barley, and oats have less gluten than wheat, and maize has one, and therefore wheat, despite its higher cost, yields the most nutriment for a given sum. It is possible that of the various wheat flour those containing part of the bran—entire wheat and flours—furnish the body with more mineral matters than fi flour, but they probably do not yield more digestible protein for a time supposed. It seems safe to say that, as far as know, for a given amount of money white flour yields the mo nourishment with the various food ingredients in the best pro

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[1] U. S. Dept. Agr., Office of Experiment Stations Buls. 35 and 52.

The raising or leavening of bread is usually brought about b yeast develop in it. These minute plants feed upon suga dough and in their growth give off alcohol and carbon dio which latter, expanding with the heat, forces its way through th and thus lightens it. In order to give the yeast a better c work, the dough is usually "set to rise" for some hours before into the oven. There are many methods of growing yeast at in the bakery, but the compressed yeasts now in the market give equally good results with so much less labor that their us United States at least, is becoming practically universal.

The lightness and sweetness of bread depend as much on in which it is made as on the materials used. The greatest car be used in preparing and baking the dough and in cooking an ing the finished bread. Heavy, badly raised bread is a very da food, and unfortunately very common, and probably more ind has been caused by it than by all other badly cooked foods.

As compared with most meats and vegetables, bread has pr no waste and is very completely digested. It is too poor in pr be fittingly used alone, but when used with due quantities o foods it is invaluable, and well deserves its title of "the staff o

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## FARMERS' BULLETIN No. 121.

# NS, PEAS, AND OTHER LEGUMES AS FOOD.

BY

MARY HINMAN ABEL.

[Revised November 15, 1906.]

REPARED UNDER THE SUPERVISION OF THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

WASHINGTON:
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1911.

# LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
*Washington, D. C., November 15, 1906.*

Sir: I have the honor to transmit herewith an article on beans, s, and other legumes as food, prepared by Mrs. Mary Hinman el, in accordance with instructions given by the Director of this ce.

A number of popular bulletins have been published by this Department in the past, summarizing the available information on different d materials which enter largely into the diet of most families. e present article is similar in scope to those published earlier. s. Abel has made an extensive study of the literature of the subt, and has also embodied the results gained by practical experience d many experiments, some of which were undertaken especially in nection with the present work. The relatively small number of inite investigations on the comparative value of different leguminous vegetables, and the lack of data regarding the effects of different hods of cooking, upon digestibility and similar topics emphasizes need of more knowledge.

n preparing this revision of the bulletin some results of investigas, which have appeared since it was first issued, have been added. ome of the illustrations used are from original drawings, others adapted from Vilmorin-Andrieux's "Vegetable Garden," and er well-known works.

t is believed that this article is a useful summary of available rmation on the subject, and its publication as a Farmers' Bulletin herefore recommended.

Respectfully,
A. C. True,
*Director.*

Hon. James Wilson,
*Secretary of Agriculture.*

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# BEANS, PEAS, AND OTHER LEGUMES AS FOOD.

## INTRODUCTION.

The word legume is used by botanists to denote the one-celled two-valved seed pod, containing one or more seeds, borne by plants of the botanical order Leguminosæ. The most common representatives of this family which are used as food are the various kinds of beans and peas. In common usage the term is applied to the plants themselves, which are hence called leguminous plants or legumes. The term pulse is also sometimes applied to this class of plants. The papilionaceous or butterfly-shaped flowers and the pendent pods of the pea and bean are familiar in every garden, while the ripened seeds of the pea, bean, lentil, and peanut are among the standard food stuffs offered in our markets. Taking the world over, the legumes are, next to the cereals, the most valuable and the most extensively used among vegetable foods. The seeds are eaten green, either alone or with the pod, as in the case of string or snap beans and edible podded peas, and also in the fully ripened state, as split pea, dried bean, lentil, and peanut. Most species of the pea and bean have been greatly improved by the gardeners' art.

## GEOGRAPHICAL DISTRIBUTION.

Representatives of the legume family are found in all climates and countries. The pea and bean grow rapidly, three to four months being sufficient to bring most varieties to maturity, and consequently they can be grown in the short summers of far northern lands, the pea, the most hardy of them, at least as far as 67° north latitude; and, as they also stand high temperatures, they are all largely cultivated in tropical and subtropical regions. The pea is the favorite legume of middle and northern Europe, while in the Mediterranean countries the bean is grown more generally than the pea. In nearly all sections of our own country both the pea and bean are grown extensively, and are even exported. Peanuts of a superior quality are cultivated in our Southern States. So far as can be learned, the lentil is at present grown in this country only to a small extent in the southwestern portion of the United States.

## THE BEAN.

This valuable legume is known to have been cultivated by the Egyptians, the Greeks, and the Romans. The Romans used the broad bean (*Vicia faba*) in voting and in certain ceremonies. Early voyagers to the Western Continent speak of beans and peas as being cultivated by the Indians in different parts of North and South America, and we know that the Algonquins had one and perhaps two varieties of pole beans. The Indian name for the bean means "to wind about." Champlain, in 1604, describes the planting of what he calls the "Brazilian bean" in the region of the Kennebec. He says it grew 5 to 6 feet high and wound around the corn. It is certain that before 1600 A. D. beans were cultivated as far north as the St. Lawrence, and they were recognized by travelers as "proper to the country." Bean flour is spoken of as in use among the Aztecs. Beans are now widely distributed, one or more varieties being grown in all temperate, tropical, and subtropical countries.

The main species of beans are briefly discussed below.

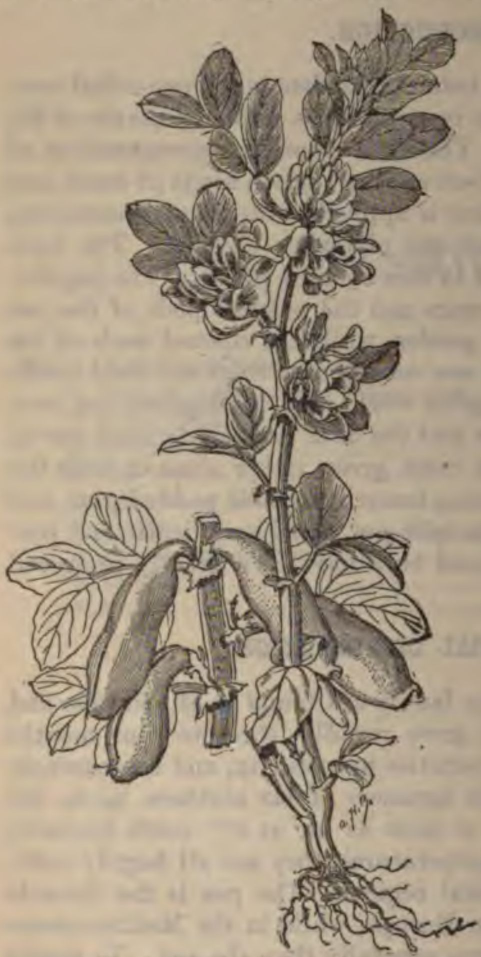

FIG. 1.—Broad or Windsor bean.

### BROAD OR WINDSOR BEAN

### (Vicia faba).

This is the "bean of history," or that which was earliest cultivated. This bean (fig. 1) grows erect, about 2½ feet high, has a square, reddish stem, and the leaves are made up of oval leaflets. The pods are broad, thicker at the end, and generally curved and pendent, containing thickish, bulging seeds. Several varieties are grown in Europe, both for fodder and for human food, but it does not continue as long in bearing as other beans. It is said to be more generally eaten there e poor than by the wealthy, but, as it has a distinct and agree- flavor of its own, quite different from the kidney bean, it should etter known among us. It is gathered when full grown, but e, as it is then best flavored. The Broad Windsor is perhaps the nown of the cultivated varieties but it is less successfully grown e United States than in Europe, the climate being apparently ted to its best development. It is imported to some extent in nge for varieties grown here.

### KIDNEY BEAN (Phaseolus vulgaris).

is species, with its numerous varieties, comprises all beans ordi- y used among us except the Lima bean. It is a native of a warm te, probably of South America, was introduced into Europe in sixteenth century. It was not vn to the ancients. It has since me very important, chiefly be- e varieties of it are easily pro- ed by the gardener and the qual- thus improved by cultivation. at is called the "keel" in papil- aceous flowers is somewhat re- ed in the kidney bean and with pistil is spirally coiled. Cross tilization with different varieties said to be easily brought about. s naturally a climber, but dwarf ieties have been developed which call bush beans, which are used h as string or snap beans and as ed beans. This bean grows rap- , flowering and seeding early. It large, rough leaves, made up of ee leaflets, and the butterfly-shaped blossoms, in clusters of from to eight, start at the axils of the leaves. The pods and seeds variously shaped and colored. The kidney beans may be divided two groups—tough podded and edible podded (fig. 2), there ng both bush and pole varieties of each group. A great number varieties have been developed, each locality having its own favor- , and the tendency of growers to rename standard varieties or se which have developed only unimportant differences tends to fuse the nomenclature. The many "wax" beans belong to this cies. Most of the "shell" beans which are eaten before fully ripe of the pole varieties. The prejudice against beans that grow dark

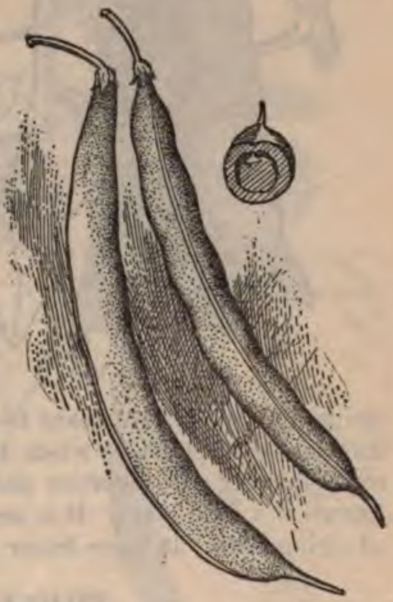

FIG. 2.—Snap or edible podded kidney bean.

in cooking is unfortunate, since many of them are of fine quali full flavored.

**LIMA BEAN** (Phaseolus lunatus).

This bean is of South American origin, a tall climber, be very flat, broad pod, with short, flat seeds, slightly kidney-shap of the halves nearly always larger than the other and wrin fluted (fig. 3). The bean is of excellent and a favorite shell both green and ripe cially in the United There is also a cultur ety of bushy habit.

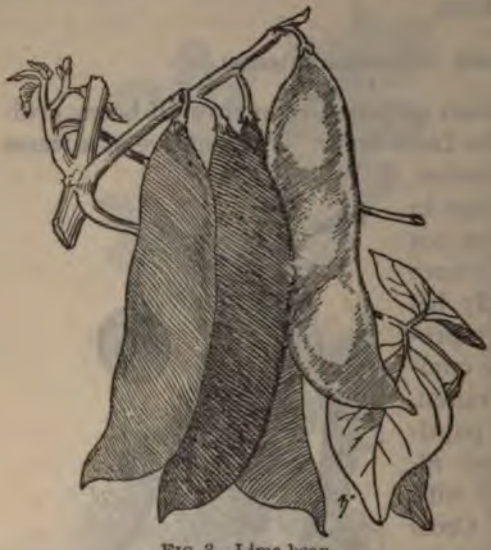

FIG. 3.—Lima bean.

**SCARLET RUNNER** ( lus multiflorus).

This species, famil an ornamental climb seldom used as food United States, is con ably used for that pu in Europe, especial England, some variet ing often preferred b string and green shell beans to the kidney bean. They are, ho inferior to other beans when dry. It seems strange that this some climber, of vigorous and rapid growth, should be so known as a food plant. It is used while young and tender in th of string bean. It bears better if the growing points are pinc

**FRIJOLE** (Phaseolus spp.).

Another species which should be noted as being of local rath general importance is the frijole (*Phaseolus* spp.) of Mexico Southwestern Territories, a small, flat bean frequently of a brown or light tan color. Various other colors are also found next to maize, the staple food in those regions. It is largely u as a green or snap bean. Either green or dry it is an almo food with the Mexicans or natives of Spanish-Indian descen

It would seem that the dry frijole might well be used farthe Several varieties that have been tried are very good both in s as a vegetable.

## COWPEA (Vigna catjang).

he cowpea (fig. 4) belongs to the bean family; but it is the “ field ” of the Southern States. There are several varieties—the “ red ” “ black ” varieties, the round “ lady ” peas, the large “ black-eye ” “ purple-eye,” and the variously mottled and speckled “ whip-rwill ” peas, besides many others. There are both trailing and h varieties. The plant bears a leaf with three leaflets and long ls growing in pairs on a long stem. The cowpea has been grown at least one hundred d fifty years in our uthern States, the seed ving been brought from dia or China. It is own both as a forage ant and for human food, t mainly as a fertilizer r the soil (green ma- re). Considerable quan- ies of the cowpea are nsumed during the sea- n, being gathered when e pods begin to change lor and before they be- me dry. For winter use e dry peas are cooked e other dried beans and ve a very agreeable vor.

The cowpea requires a nger season than the kid- y bean and will seldom, ever, mature in the cli- ate of New England. ut as a dry bean it might ell be introduced into r northern markets on count of its distinctive and agreeable flavor.

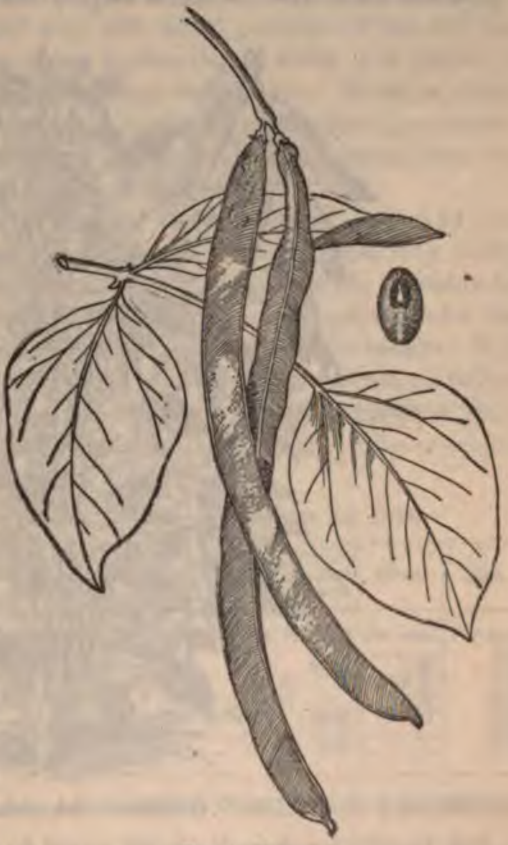

FIG. 4.—Cowpea.

## SOY BEAN (Glycine hispida) AND ITS PREPARATIONS.

“ The soy bean (fig. 5) is an erect annual plant, with branching iry stems, trifoliate, more or less hairy leaves, rather inconspicuous le lilac or violet colored flowers, and broad two to five seeded ds covered, like the stem, with stiff reddish hairs. The seeds vary color from whitish and yellowish to green, brown, and black; and

in shape from spherical to elliptical and more or less compresse
The plant may reach a height of 4 feet or more.

This leguminous plant, probably native in China, is the most im
tant legume of China and Japan. Its remarkably high percentag
protein (34 per cent) and fat (17 per cent) attracted the attentio
Europeans some twenty-five years ago. Since that time it has
cultivated to some extent, both in Europe and America, chiefly
forage and soiling crop. In the Orient this bean and the various
products made from it are so largely consumed that it is perhaps

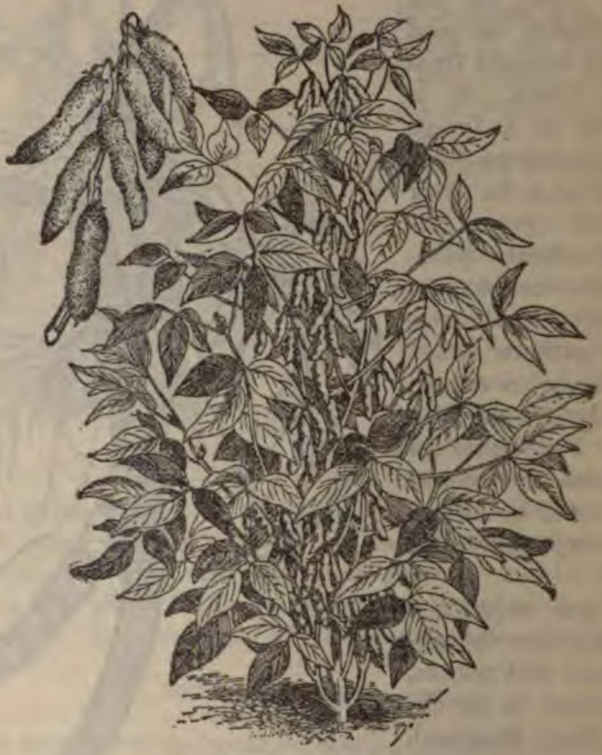

FIG. 5.—Soy bean.

most important food plant next to rice. The soy bean is eat
a small extent boiled like other beans, but in China and Japan
elaborated into a variety of products, all of which have a high
centage of protein, and when eaten in connection with the staple
rice, which is so deficient in that constituent, helps to make a
balanced dietary. Some one of these products is eaten at pe
every meal and by rich and poor alike, especially in the interi
these countries, where sea food is not obtainable. One of the

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[1] U. S. Dept. Agr., Farmers' Bul. 58.

important of these preparations is shoyu, and it is the only one that has been introduced to any extent into other countries, where it is known as soy sauce. To make it, a mixture of the cooked beans with roasted wheat flour and salt is fermented for some years in casks with a special ferment. The result is a thick brown liquid having a pungent and agreeable taste.

There are also several varieties of bean cheese or similar products made from this legume which are very important foods. These are natto, miso, and tofu. Natto is made from soy beans that have been boiled for several hours until very soft, small portions of the still hot mass being then wrapped securely in bundles of straw and placed in a heated, tightly closed cellar for twenty-four hours. Bacteria, probably from the air or the straw, work in the mass, producing an agreeable change in its taste. Miso is a fermented product made from soy beans rubbed to a paste with barley and salt.

For tofu, the soy bean, after soaking and crushing, is boiled in considerable water and filtered through cloth. To the resulting milky liquid 2 per cent of concentrated sea brine is added, which, probably by virtue of the calcium and magnesium salts present, precipitates the plant casein, which is then pressed into little snow-white tablets. It is made fresh every day. Tofu is sometimes cooked in peanut oil before it is eaten. In natto and miso the action of minute organisms plays an important part. In tofu there is no such action. The composition of a number of these products is as follows:

Table 1.—*Composition of food products made from soy beans.*

| Soy-bean food products. | Water. | Protein. | Fat. | Nitrogen-free extract. | Fiber. | Ash. |
|---|---|---|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Fresh tofu | 89.00 | 5.00 | 3.40 | 2.10 | .......... | 0.50 |
| Natto | 15.32 | 41.42 | 23.65 | 15.05 | 1.48 | 3.08 |
| White miso | 50.70 | 5.70 | 24.40 | | 12.60 | 6.60 |
| Red miso | 50.40 | 10.08 | 18.77 | | 8.25 | 12.50 |
| Swiss miso | 12.53 | 26.43 | 13.91 | 19.54 | 1.41 | 26.18 |
| Shoyu | 63.29 | 8.31 | .......... | 5.10 | .......... | 19.45 |
| Do | 67.42 | 7.37 | .......... | 4.06 | .......... | 17.47 |

## LABLAB BEAN (Dolichos lablab) AND OTHER UNCOMMON VARIETIES.

There are several kinds of beans which, though articles of diet in Oriental countries, are used only to a limited extent in the United States, usually by Chinese or other residents of foreign birth or extraction. Lablab beans (*Dolichos lablab*); asparagus bean (*Dolichos sesquipedalis*), and mungo bean (*Phaseolus mungo*), may be mentioned. The green pods of the asparagus bean (fig. 6) are largely used as a snap bean. The pods are long, containing 10 to 16 seeds, more slender than string beans, and slightly ridged along the middle of the two valves. Under the name of "tou kok" this vegetable is cultivated by the Chinese in some regions of California, and is said to

be finding favor with the white residents, being considered a val
variety of snap bean.

### LOCUST BEAN (Ceratonia siliqua).

There is still another bean which may be said to be among our
food products since the pod is regularly found in a dried state o
confectioner's stands and sold under the name of St. John's br
It is the carob or locust bean (*Ceratonia siliqua*), grown on the sh
of the Mediterranean Sea as food for cattle. It is also eaten to a
siderable extent by the poorer people. The ripe seeds are surroun
by a sweet mucilaginous pulp of agreeable flavor. When dried
sugar content is as high as 50 per cent. Similarly, portions
pods of the so-called honey locust (*Gleditschia triacanthos*)
eaten to a limited extent in this country.

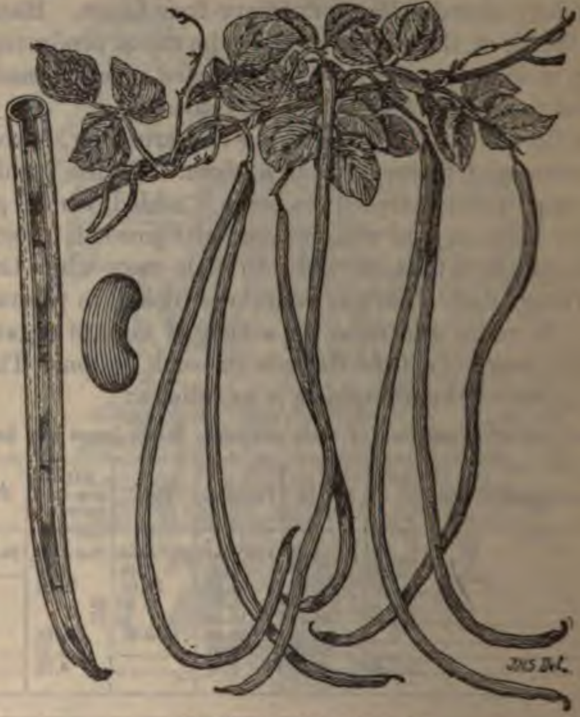

FIG. 6.—Asparagus bean.

### THE PEA.

The pea was originally from a more northern clime than
bean, and it has probably been cultivated from very early
although it does not seem to have been known to the Gre
Romans. It appeared in Europe in the Middle Ages, but it
cultivated in England even in the time of Elizabeth. Full

that peas were brought from Holland and were accounted "fit dainties for ladies, they came so far and cost so dear." From the market gardener's point of view, the pea is the most important of the legumes. In this country and in Europe great quantities are consumed in the green or unripe state, and in Europe the dried or "split" pea is as largely used as the dry bean; with us it is less popular.

### FIELD PEA (Pisum arvense).

The field pea, also known in some regions as the Canadian field pea, has many varieties. Often the blossoms are colored and the seeds more or less spotted with brown. The field pea is most commonly grown for fodder, although some varieties are often eaten as a table vegetable. When two-thirds grown the seed is delicate and well flavored, and the field pea has the advantage of a longer season than the garden pea. Large quantities of the dry seed are used in the manufacture of split peas.

### GARDEN PEA (Pisum sativum).

The garden pea (fig. 7) has many varieties, but they are kept only by great care, as they easily revert to the original type. The cultivated pea has slender, hollow stems bearing compound leaves and terminating in tendrils which attach to any near object. The flowers, generally white, are produced in the axils of the leaves and are followed by pods containing a number of green seeds which are light green when unripe and green or white when ripe.

The garden pea is divided into tough podded or shelling peas, the only kind in general use in this country, and the edible podded or sugar peas. Both kinds may be tall, dwarf, and half dwarf.

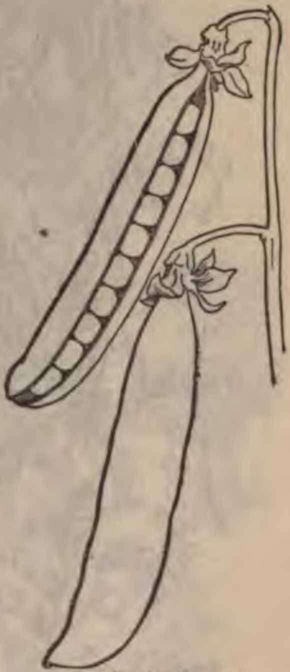

FIG. 7.—Garden pea.

Shelling peas are again divided into the smooth or round seeded and the wrinkled kinds. Many varieties of both have been developed by the gardener. There is indeed a useless multiplication of names and varieties.

The edible-podded peas (fig. 8) deserve to be better known among us. Many varieties are successfully cultivated in Europe, but here as yet they are grown chiefly by amateurs and are hardly in the market. The seed is furnished, however, by most growers. This pea has a very tender pod, the ordinary parchment-like lining be attenuated. The pod is thicker and more fleshy than the pod of the shelling pea. It is gathered when the pea is just forming and used, pod and all, exactly like string beans. Some varieties tested were found to be excellent in flavor and texture.

### CHICK-PEA OR GRAM (Cicer arietinum).

A shelling pea, practically unknown here, is the chick-pea (*Cicer arietinum*, the garbanzos of Spanish cookery, or the gram of India. It is largely cultivated in southern Europe, in Spanish America, and many parts of the East, especially British India, whence it is exported. It is a stiff, upright plant, covered with hairs and bearing inflated pods containing a few curiously shaped seeds; the two lobes distinctly marked and the germinal point very prominent.

These peas are eaten boiled, but more commonly roasted. This roasted pea seems to have been much in use in Roman times, the phrase *fricti ciceris emptor*, "buyer of roasted chick-peas," meaning in conversation a poor fellow.

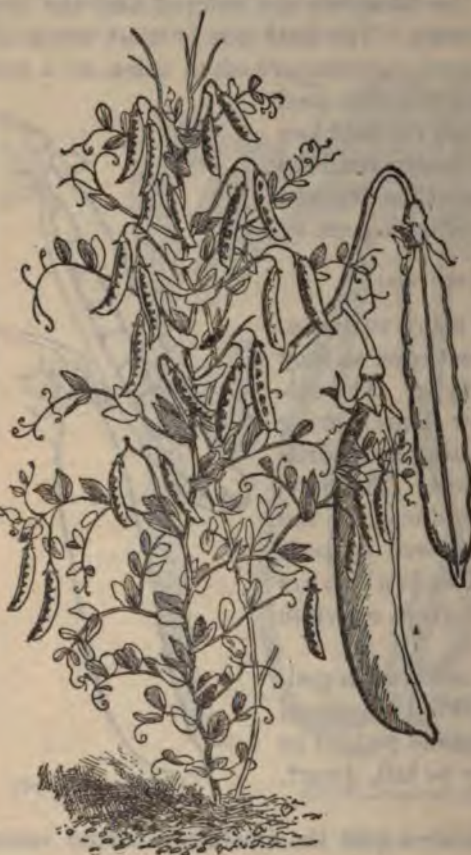

Fig. 8.—Edible podded or sugar pea.

### THE LENTIL (Lens esculenta).

The lentil (fig. 9) is a small branching plant with delicate pea-like leaves. The small white flowers growing in pairs are followed by flat pods, each containing two very flat round seeds, convex on both sides. Unlike the pea and bean, the lentil is eaten only when fully ripe. The brown or reddish lentil is smaller than the yellow, but of more delicate flavor.

The lentil is one of the most ancient of food plants, probably one of the first to be brought under cultivation by man. It has been grown from early times in Asia and in the Mediterranean countries. The reddish Egyptian lentil probably furnished the "red pottage" of Esau. In Europe this legume is far less grown than the pea and bean, partly because its yield of seed and straw is less; therefore the market is partially supplied from Egypt. The lentil, according to analysis, is one of the most nutritious of all the legumes, but its flavor is pronounced and to some persons not as agreeable as that of the pea and bean. It has sometimes been claimed that indigestion and other bad effects followed the eating of lentils, but this impression is known in some cases to be traceable to the use of certain poisonous vetches, whose seed much resembles the lentil. There is every reason to consider the lentil a wholesome food. Until recent years the lentil was little known in the United States, but with the growth of the foreign population its use has steadily increased. The lentils found in our markets are all imported, but the culture of this legume with European seeds is being tried in the southwestern United States and elsewhere. There is already grown in New Mexico and Arizona, as well as in Mexico, a small variety of lentil, the seed of which was doubtless brought from Spain centuries ago by the ancestors of the present mixed race living there. The sandy soil of moderate fertility seems adapted to it; it has become acclimated, is hardy and prolific.

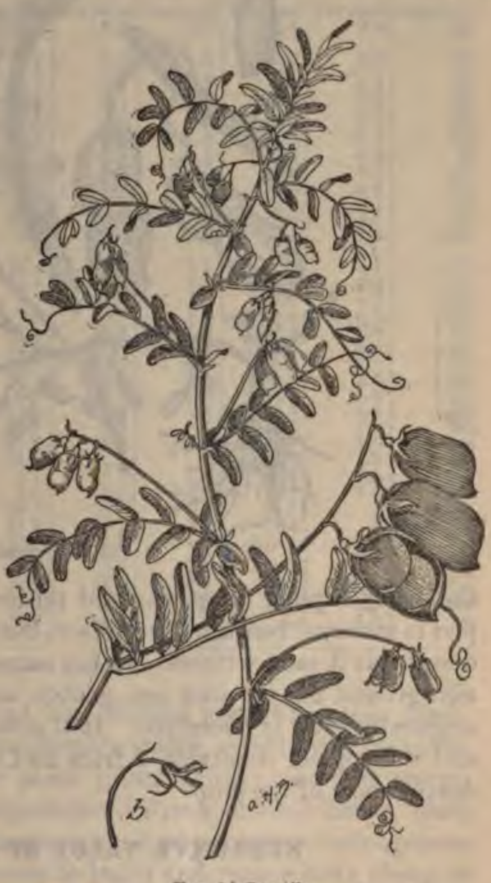

FIG. 9.—Lentil

### THE PEANUT (Arachis hypogæa).

The peanut (fig. 10) is so different in appearance from the bean and pea and is put to such different uses that it is seldom thought of as a legume, but a study of the growing plant immediat resemblance. Here we see the same struggling, more or less trailing, annual, with characteristic leaves, and the butterfly-shaped blossom, whose ovary develops into a seed pod. The manner of growth from this point is very peculiar; as the flower withers the stalk or spike of the ovary rapidly lengthens and pushes into the ground, so that the pod is matured beneath the surface, but if the spike is prevented from doing this it soon withers. Other names for this plant are the earth-nut, ground nut, ground pea, goober, and pindar. Where the peanut originally grew is uncertain. It is now widely distributed in tropical and subtropical countries, Africa and our own Southern States producing most of the crop.

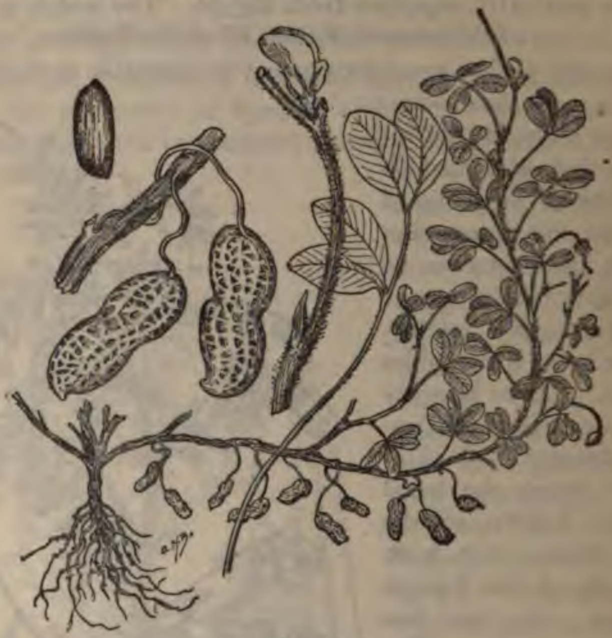

FIG. 10.—Peanut.

## NUTRITIVE VALUE OF THE LEGUMES.

The different kinds of legumes are so similar in their general character, nutritive constituents, and digestibility that in these respects they may be treated together. Even in an immature state, as green peas and beans, they are, as regards composition, equal or superior in nutritive value to other green vegetables, and the ripened seed shows by analysis a very remarkable contrast to most of the matured vegetable foods, as the potato and other tubers, and even to the best cereals, as wheat. This superiority lies in the large amount of nitrogen in the form of protein that they contain.

A comparison of some of the more common fresh and dried legumes with other food materials is shown in the following table:

TABLE 2.—*Composition of fresh and dried legumes compared with that of other foods.*

| Material. | Water. | Protein. | Fat. | Carbohydrates. | Ash. | Fuel value per pound. |
|---|---|---|---|---|---|---|
| Fresh legumes: | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Calories.* |
| String beans | 89.2 | 2.3 | 0.3 | 7.4 | 0.8 | 195 |
| Whole pods of *Dolichos sesquipedalis* | 79.9 | 4.5 | .5 | 13.9 | 1.2 | 365 |
| Sugar peas or string peas | 81.8 | 3.4 | .4 | 13.7 | .7 | 335 |
| Shelled kidney beans | 58.9 | 9.4 | .6 | 29.1 | 2.0 | 740 |
| Shelled Lima beans | 68.5 | 7.1 | .7 | 22.0 | 1.7 | 570 |
| Shelled peas | 74.6 | 7.0 | .5 | 16.9 | 1.0 | 465 |
| Shelled cowpeas | 65.9 | 9.4 | .6 | 22.7 | 1.4 | 620 |
| Canned string beans | 93.7 | 1.1 | .1 | 3.8 | 1.3 | 95 |
| Canned Lima beans | 79.5 | 4.0 | .3 | 14.6 | 1.6 | 360 |
| Canned kidney beans | 72.7 | 7.0 | .2 | 18.5 | 1.6 | 480 |
| Canned peas | 85.3 | 3.6 | .2 | 9.8 | 1.1 | 255 |
| Canned baked beans | 68.9 | 6.9 | 2.5 | 19.6 | 2.1 | 600 |
| Peanut butter | 2.1 | 29.3 | 46.5 | 17.1 | 5.0 | 2,825 |
| Dried legumes: | | | | | | |
| Lima beans | 10.4 | 18.1 | 1.5 | 65.9 | 4.1 | 1,625 |
| Navy beans | 12.6 | 22.5 | 1.8 | 59.6 | 3.5 | 1,605 |
| Frijoles | 7.5 | 21.9 | 1.3 | 65.1 | 4.2 | 1,695 |
| Lentils | 8.4 | 25.7 | 1.0 | 59.2 | 5.7 | 1,620 |
| Dried peas | 9.5 | 24.6 | 1.0 | 62.0 | 2.9 | 1,655 |
| Cowpeas | 13.0 | 21.4 | 1.4 | 60.8 | 3.4 | 1,590 |
| Soy beans | 10.8 | 34.0 | 16.8 | 33.7 | 4.7 | 1,970 |
| Chick-pea[a] | 14.8 | 12.4 | 6.7 | 63.3 | 2.8 | 1,690 |
| Peanuts | 9.2 | 25.8 | 38.6 | 24.4 | 2.0 | 2,560 |
| St. John's bread (carob bean)[a] | 15.0 | 5.9 | 1.8 | 75.3 | 2.5 | 1,565 |
| Potatoes | 78.3 | 2.2 | .1 | 18.4 | 1.0 | 385 |
| Cabbage | 91.5 | 1.6 | .3 | 5.6 | 1.0 | 145 |
| Tomatoes | 94.3 | .9 | .4 | 3.9 | .5 | 105 |
| Rolled oats | 7.7 | 16.7 | 7.3 | 66.2 | 2.1 | 1,850 |
| Wheat breakfast foods | 9.6 | 12.1 | 1.8 | 75.2 | 1.3 | 1,700 |
| Spring-wheat flour | 12.3 | 11.7 | 1.1 | 74.5 | .4 | 1,650 |
| Winter-wheat flour | 11.9 | 10.7 | 1.0 | 75.8 | .6 | 1,650 |
| Lean beef | 70.0 | 21.3 | 7.9 | ---------- | 1.1 | 730 |
| Dried beef | 54.3 | 30.0 | 6.5 | .4 | 9.1 | 840 |
| Milk | 87.0 | 3.3 | 4.4 | 5.0 | .7 | 325 |
| Cheese | 34.2 | 25.9 | 33.7 | 2.4 | 3.8 | 1,950 |
| Butter | 11.0 | 1.0 | 85.0 | ---------- | 3.0 | 3,605 |
| Eggs | 73.7 | 14.8 | 10.5 | ---------- | 1.0 | 720 |

[a] European analysis.

Fresh string beans, sugar peas, and shelled peas, like other fresh, succulent vegetables, contain considerable water, which, with the materials dissolved in it, forms the plant juice. They somewhat resemble cabbage in percentage composition. Fresh shelled beans, peas, and cowpeas contain a fairly large amount of protein or nitrogenous material, the nutrient which serves to build and repair body tissue as well as to furnish energy. They also contain considerable carbohydrates and small amounts of fat, both these classes of nutrients serving to supply the body with energy. The amount of ash or mineral matter in the lugumes varies in amount. It doubtless serves the same purpose in the body as mineral matter found in other food materials. The canned legumes, which are simply cooked foods sterilized and kept in such a way that they can not ferment, resemble in composition the same materials uncooked. The dried legumes contain
though to the eye they seem to be perfectly dry. They

high percentage of protein, in this respect surpassing the other seeds commonly used as food, such as wheat. They approach animal foods as regards protein and total nutritive value, most of the legumes containing carbohydrates in place of the fat found in animal foods, though the proportion of fat may be high, as shown by the soy bean, with 17 per cent, and the peanut, with about 40 per cent, or even more. However, the relative proportion of fat and carbohydrates in food may vary within rather wide limits, since these food constituents serve the same purpose in the body, although the fats yield two and one-fourth times as much energy per pound as carbohydrates.

The fat[a] of beans when extracted is a light yellow oil resembling olive oil in appearance, which solidifies readily at a low temperature and becomes liquid again on warming. The fat of other legumes would doubtless be more or less similar in its properties. Soy-bean oil is extracted and finds important uses in China and Japan. Peanut oil is extracted in large quantities and is an important commercial product. It is spoken of on page 35.

The carbohydrate group in beans, and doubtless in other legumes also, is in general made up of starch, sugar, and crude fiber. It is worthy of note that soy beans when well ripened contain little if any starch and on this account they have been recommended for the use of diabetics. The ash of legumes contains similar mineral constituents to those of other plants. It has been found that both iron and potassium are specially abundant in bean ash, one authority stating that about 80 per cent of the ash of beans is potassium phosphate. The proportion of ash is in general relatively large.

### NITROGENOUS CONSTITUENTS.

Vegetable foods are nearly all rich in starch and other carbohydrates, which supply an abundance of carbon to the system; but they contain, in general, comparatively little nitrogen, an element that is of first importance in a dietary. Therefore, the very large percentage of this constituent found in the legumes constitutes for us their special interest, and the true nature of the compounds in which this nitrogen exists is also of the utmost importance.

Most of the nitrogen found in the pea, bean, and lentil is in a form very useful as food. It was called by Liebig "plant casein," on account of its general resemblance to the casein of milk. Although its action as a food is similar to the nitrogenous matter of other vegetables, it is markedly different in some of its characteristics from, for instance, the gluten of grains. Pea and bean flour will not form a dough with water and can not be used alone for making porous bread.

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[a] Bean oil is made up of the triglycerids of fatty acids, and contains considerable quantities of lecithin and sulphur.

## DIGESTIBILITY OF THE BEAN, PEA, AND LENTIL.

Judged by the chemical analysis alone, we should give legumes the very highest place among foods, containing, as they do, more protein than the best cuts of meat, and in some cases a large percentage of fat, besides a considerable amount of starch. Pound for pound, they would thus be more valuable than meat or our best cereals. Forty years ago they were announced by Moleschott as "true treasure houses for the renewing of our blood," being equal in their albumen content "peas to veal, beans to flesh of doves, while lentils left every kind of meat far behind."

Experiments on men and animals soon made it evident, however, that the true value of a food does not depend alone on the contained nutrients, but also on the ease and completeness with which the system utilizes these nutrients, since, to use the old adage, "Man lives not by what he eats, but by what he digests." Voit pointed out as early as 1869 that vegetable foods in general were less completely digested than animal foods, for three reasons:

(1) As generally prepared and used, the nutrients of vegetable foods are inclosed in cells composed of cellulose or woody fiber, which is more or less hard and greatly interferes with their absorption.

(2) Vegetable food is prone to fermentation in the intestines, thus increasing the peristaltic movements and, if large amounts are eaten, hastening the food onward before there has been sufficient time for the absoption of its contained nutrients.

(3) The cellulose present acts as a local irritant and produces the same effect.

### PRACTICAL EXPERIENCE.

Practical experience, reaching to ancient times, testifies that beans, peas, and lentils are "hearty food." To quote the physician Galen, "they are harder to digest than other foods and give bad dreams." There is a general opinion that while they are suitable for robust people leading an active, outdoor life, indispensable to the soldier's outfit and to the logging camp, welcomed by the hunter and woodsman, and a necessary part of the food of the hard-working poor, they are, on the other hand, unsuitable for people leading a sedentary life, and are generally to be avoided by the invalid and convalescent. Such persons often complain of distress after eating beans, especially if the skins have not been removed, and of a disagreeable evolution of gas in the intestines, testifying, as it does, to the fermentability of this class of vegetables. These foods are, therefore, called "indigestible," by which is meant in common speech that they give distress or that we are unpleasantly conscious of the digestive process. These symptoms, however, do not in general indicate anything as to the extent to which the contained nutrients of a food are absorbed or used in the system. When eaten in reasonable amount by persons in health, it is doubtful if they give rise to unpleasant symptoms. That no bad results attend their use is shown by the important place they have held in the diet since early times.

## LABORATORY EXPERIMENTS.

Hoffman fed a man bread, lentils, and potatoes sufficient for his full nourishment and found that 47 per cent of the contained protein left the system unused. Of meat containing the same amount of protein, only 17.7 per cent was unabsorbed by the same person.

Woroschiloff, in comparing the digestibility of lentils with meat, found that from two to three times as much of the protein of the meat was utilized in the system as of the legume.

A very careful study was made by Strümpell of the extent of the digestibility of legumes. According to the results it would seem to depend largely on the form in which they are eaten. When he ate 250 grams (about three-fifths of a pound) of beans cooked as they ordinarily are, whole and without removing the skins, 40 per cent of the contained protein was unabsorbed or four times as much as in the case of meat. On the other hand, when he used "Leguminosenmehl," a prepared food consisting chiefly of lentil flour, only 8.2 per cent of the contained protein was unabsorbed. This equals the average digestibility of meat. As pointed out by other workers, this is, however, not a fair showing, since in order to eat enough of this lentil flour to even partially meet the conditions of the experiment he was obliged to make it up into cakes with milk, eggs, and butter, and the extent to which the nutrients of the legume were absorbed was, doubtless, much increased by the presence of stimulating animal foods.

Rubner, one of the later observers in this field, found a man who was able to eat for a few days enough cooked dried split peas (about 1.1 pounds) to fully nourish him without help from other kinds of food, peas being selected because he liked them better than beans or lentils. Even with this large quantity only 17 per cent of the contained protein was unabsorbed. It may be said that this robust individual does not represent the normal feeder, but the aim in this case is to show a comparison between this and other foods. The same man failed to use in the system 11 per cent of the contained protein of macaroni.

In some experiments recently reported by Richter the digestibility of peas was studied. The peas were cooked until soft and then passed through a sieve, some 600 grams of the purée being eaten per day. When cooked in distilled water the coefficients of digestibility were: Dry matter 92.9, protein 89.8, fat 87.6, and ash 81.1 per cent.

When cooked in hard water the coefficients were: Dry matter 91.1, protein 83.4, fat 58.9, and ash 51.8 per cent. As will be seen, the peas cooked in distilled water were the more thoroughly digested. It was also noted that the peas cooked in distilled water caused less digestive disturbance than those cooked in hard water.

In digestion experiments made at the Minnesota Experiment Station by Snyder baked beans formed a considerable part of the diet of healthy men engaged in fairly severe muscular work. The beans had been soaked in soda and water to remove the skins and were baked in the usual way, butter being added. The raw beans used had practically the composition indicated by the average figures in the table on page 17. The cooked beans naturally contained much more water (some 70 per cent) and fat (from 3 to 10 per cent) than the raw beans. When eaten with bread and milk it was found that on an average 91 per cent of the dry matter, 80 per cent of the protein, 80 per cent of the fat, and 96 per cent of the carbohydrates of the baked beans were digested. When eaten with a diet furnishing considerably more fat somewhat higher values were obtained. It was noted that the carbohydrates were more digestible than any of the other nutrients. The protein was more variable than the other constituents in digestibility, ranging in different tests from 72 to 87 per cent.

Considering the experiments as a whole, it is evident that the beans were quite thoroughly digested. It is undoubtedly true that different individuals vary in regard to their ability to digest beans, but it seems fair to conclude that when properly combined with other foods they should not be considered indigestible. As pointed out by Snyder, beans are slow of digestion and require more intestinal work than many foods, but when properly combined with other materials, so that they form a fair part of the ration, the work of digestion is more evenly distributed than when they are used alone or in very large amounts. In using beans in the dietary they are frequently eaten in excessive quantities at irregular intervals rather than in reasonable amounts combined with other foods as a regular part of the ration. It seems fair to conclude that when used in the diet in a reasonable way no difficulty is experienced in digesting beans.

## FLATULENCE.

It is a matter of common experience that after eating legumes in any quantity there occurs what is known as flatulence or the formation of gas, largely methan, in the intestines. This is not confined to people of delicate digestion, although it is to them more distressing, nor does it seem to have anything to do with the extent to which the nutrients of the food are used in the system. Experiments with ani-

mals indicate that the formation of methan is entirely due to bacte
action on carbohydrates in the intestines. Rubner's man who diges
so well the large amount of peas above cited complained very muc
this disagreeable accompaniment. In India the mungo bea
highly esteemed and is eaten by the rich and by sick people,
always "with a seasoning of asafetida to prevent flatulence."

When beans are soaked in soda and water and parboiled to re
the skins some of the germ is also removed. The opinion has
advanced that the skins and germs are the parts of the bean
are the most fermentable and produce gaseous products during
tion. Snyder, who has made a number of studies with beans
siders that treatment with a small amount of soda and salt in co
is an advantage since it hinders the formation of gas.

### DIGESTIBILITY IN MODERATE QUANTITIES.

The digestibility of legumes is thought to be largely a questi
preparation and amount eaten, as indicated above. Properly
pared and eaten in moderate quantities, peas, beans, and lenti
not be called indigestible in the ordinary sense of the word.
entire removal of the skin by sieving is to be recommended
case of persons with whom they seem to disagree.

As to the extent of the digestibility of the contained nutrients
eaten with the above restrictions, they are probably as well u
those of other vegetable foods, but less so than the nutrients of
It should be remembered that a due amount of nonabsorba
refuse matter is necessary in the food to insure the healthy act
the intestine, and it would be a great mistake to substitute, as
eral thing, highly condensed foods for those containing some
lose. None but the most hardy people could use the legumes a
sole source of nitrogenous food, since for that purpose 18
daily of dried peas or beans would be necessary for a laborin
an amount which could be furnished in not less than 6 pints of
soup; but this fact has nothing to do with their use in mo
amounts, and there is almost no dietary in which they may not
ably find a place.

In Snyder's experiments at the Minnesota Experiment Statio
a pound of baked beans was consumed per day by men engage
of the time in active outdoor work. It is his opinion, howeve
ordinarily not more than 6 ounces of baked beans, equivalen
ounces of uncooked beans, should be consumed in the daily
While beans are a valuable food, there are, as pointed out by S
certain limits to their advantageous use in the dietary. The nut
in beans are different in character from the same classes occurr
cereals and other vegetable foods and are apparently not as r

gested as those of many of the cereals, hence, beans are more suit-
le for persons engaged in active outdoor work than for those of
dentary habits. However, when properly cooked they need not be
xcluded from the dietary of those engaged in light muscular exer-
se, though they should not form as large a part of the ration as in
he case of active workingmen leading outdoor lives.

It is well known that baked beans are a very important article of
iet in lumber camps. Some recently published studies by Woods
nd Mansfield, carried on with lumbermen in the Maine woods, are of
terest in this connection. The diet was made up of a few staple
ods, such as bread, salt pork, beans, corned beef, salt fish, some
getables, a few simple cakes and other pastry, molasses and tea.
nsidering the average of six digestion experiments it was found
at baked beans furnished about one-third of the total protein and
out one-eighth of the total energy of the diet. Although so large
proportion of the nutrients came from beans, the diet seemed to
well assimilated, on an average 85 per cent of the protein, 97 per
nt of the fat, 98 per cent of the carbohydrates, and 88 per cent of
e ash being digested, and 93 per cent of the fuel value of the diet
ing available.

### DIGESTIBILITY OF PEAS.

In a number of experiments made by Snyder, at the Minnesota
xperiment Station, pea soup made of dried peas formed a consider-
le part of the ration, this dish being selected because dried legumes
e a cheap source of protein and it was of interest to learn how they
mpare in digestibility and nutritive value with other proteid
ods.

The calculated coefficients of digestibility for protein and carbo-
ydrates of peas are 80 and 96 per cent, respectively. The value for
rotein is somewhat less than the average value for wheat flour, but,
s Prof. Snyder points out, the total amount of protein in dried peas
s much larger than in flour, so a pound will furnish about twice
s much digestible protein as a pound of flour. A pound of dried
eas costing 8 cents contains 0.17 pound digestible protein, which
s as much as is found in a pound of the edible portion of any of the
ommon meats. As a cheap source of protein, therefore, Snyder con-
ludes that dried peas are a valuable addition to the dietary, par-
icularly for combination with such starchy foods as bread, potatoes,
tc., to make a well-balanced ration.

### DIGESTIBILITY OF PEANUTS.

The peanut is remarkable among the legumes for its large propor-
ion of fat (39 per cent) and its resemblance in taste and use to the
rue nuts, and, indeed, it is popularly classed with the nuts. At pres-

ent there is a good deal of interest in nuts as food, and perhaps on this account peanuts in the form of peanut butter (see p. 35) and in other forms are used to a greater or less extent as articles of diet by many families. That it is perfectly possible to provide a diet in which the bulk of the protein is furnished by peanuts or other nuts is shown by the results of some recently published experiments carried on by Jaffa at the University of California. The men studied lived in health on rations composed largely of nuts and fruits, peanuts being used in several cases. It should be borne in mind, however, that experience does not indicate that a diet restricted to such foods possesses the marked advantages which some of its advocates have claimed. It is worth noting that in the southern United States and other regions where peanuts have been long cultivated they have not come to be staple articles of diet but have remained food accessories for occasional use.

Few experiments have been made to show how thoroughly peanuts are digested. In connection with his investigations, Jaffa studied the digestibility of a ration made up of peanuts and Japanese persimmons with small amounts of a cereal breakfast food, olive oil, tomatoes, and milk. In round numbers, 87 per cent of the protein, 89 per cent of the fat, and 90 per cent of the carbohydrates eaten were digested, and 85 per cent of the energy of the ration made available. When the daily fare consisted of peanuts, apples, and dates with small amounts of other food as before, the coefficients of digestibility were much the same. These figures would indicate that the peanuts were quite thoroughly digested.

There are many persons who find that roasted peanuts eaten in any quantity are indigestible in the sense of bringing on pain or distress. This is probably on account of their rich concentrated character, though sometimes this distress seems to be due to eating peanuts which are roasted until they are very brown. It seems to be a fact that when peanuts are eaten in connection with other food, as bread, the ill effects are less marked. Furthermore, they should always be thoroughly masticated.

## EXTENT TO WHICH LEGUMES ARE USED IN DIETARIES.

Since, as we have seen, peas, beans, and lentils contain as much protein as meat, and no other vegetable foods can approach them in this regard, we need not be surprised to learn that they are extensively used among all people who, either from necessity or from choice, eat little or no meat. This is but one of many instances of a wise choice of food made long before exact knowledge was able to give the reason for it.

Some food rich in protein will be found in the daily diet of all peoples. The Mongol eats with his rice, which is largely starch, small quantities of fish, fish eggs, and goose livers, but for his supply of proteid material he relies on his different preparations of bean cheese and on soja sauce made from the soy bean. The Mexican, whose supply of meat is scanty and of a poor quality, uses the native bean or frijole at almost every meal, made into a stew with vegetables and perhaps shreds of sun-dried beef, well spiced with the chili or red pepper. The cooking is said to be done now in the unsightly American tin can (in this case a lard or kerosene can), which has almost supplanted of late years the primitive earthen pot described by travelers. The bean stew or porridge, with the tortilla or cake of pounded corn, makes up the bulk of his food. The puchero or daily stew eaten by the poorer class of Spaniards has lentils for its basis, and with the Bedouins and other Asiatic people the porridge of lentils is in constant use. Church mentions twenty species of legumes, some having many varieties, that are raised in India, and there they form not an occasional but a staple food among a people who, both by poverty and by religious scruples, are prevented from eating meat. There is a Hindoo proverb, "Rice is good, but lentils are my life." The Roman proverb, "The poor man grown rich no longer delights in lentils," intimates that though indispensable to the man of slender purse their too familiar flavor was gladly exchanged for the more expensive dish when it could be afforded. The legumes have been called the "meat of the poor." Nitti, an Italian writer, tells us that the Neapolitan bricklayers, restricted by their scanty wages to cheap food, but requiring food that is rich in protein, condemn themselves to a daily diet of kidney beans, a vegetable which is at the same time the cheapest and the richest in protein. With the Hindoo the lentil is reputed to have great staying power, and it is a favorite food among those who are to undertake long journeys. Parched as we parch corn, it is much esteemed in Egypt and Syria for this purpose. Arabs feed their horses ground beans to prepare them for extraordinary exertions.

In early days in the New England States the woodcutter who went out for a day's work in the woods in winter almost always took with him "bean porridge," i. e., beans that had been cooked to the consistency of a thick mush and then frozen in bowls. In each bowl had been placed a string, which served to lift out the contents. By the help of the camp fire the frozen cooked beans were again made into porridge.

In the dietary studies made in connection with the nutrition investigations of the Office of Experiment Stations of the United States Department of Agriculture and the earlier work from inquiry developed, calculations were mad total nutrients furnished by a number foods. Taking the average of some fourte men of varied income and living in diffe constituted 0.6 per cent of the total food a the total protein of the diet—a small am value is considered. Wheat flour furnish food and eggs 2.2 per cent, or 17.1 and 4 the total protein. Considering the averag studies with mechanics' families and t legumes furnished 1 per cent of the total cent of the total protein, the proportions and eggs being somewhat greater than in professional men. In studies of the food it was found that baked beans furnished 2 protein and 10 to 14 per cent of the tota p. 25.) The native inhabitants of the and Mexico are reported to consume lar other legumes. The average of four laborers living in New Mexico shows tha 9.4 per cent of the total food and 21.3 p In this case eggs furnished only 0.8 per c per cent of the total protein, while wheat and 21 per cent, respectively. In the mechanics, and farmers the total amoun small, and in view of the high food valu of this class of foods it might have been

## PREPARATION OF LEGUM

Since legumes are to be counted among able food stuffs, if their continued nutr choice and preparation is a matter of im used—

(1) Chiefly for the tender pod, which gathered when the seed is less than half bean and sugar pea.

(2) The nearly grown but unripe seed,

(3) The fully ripened seed, as the d peanut.

(4) The flour or meal made by grindin pea, or lentil—and the "butter" ground

The number of special food products is small as compared with cereal produc been steamed and rolled flat like rolled is claimed that these have the advantage of not requiring long cooking when used for soups, etc. Specially prepared dried beans are sold from which the skin and germ have been removed with the idea of making the product more wholesome.

### STRING BEANS AND SUGAR PEAS.

French beans (*haricots verts*), snap or string beans, are the immature fruit pods of several varieties of the kidney bean, both the dwarf and the climbing. The best have little or no "string," some requiring no preparation for cooking. They must be freshly gathered and so young that the beans are hardly noticeable when they are cooked. After the string, if present, is removed, the pods are cooked, either whole or broken into bits. The German method is to cut them transversely a few times or "whittle" them. This seems to shorten the time of cooking and to allow of better distribution of seasoning. They are then boiled in salted water and drained, or the water may be thrown away after a few moments of boiling, the beans being then stewed in as little water as possible and the seasoning added when they are half done.

When the beans form the main dish of the meal, a piece of fat meat is often cooked and eaten with them. When the bean of most varieties is more than half grown the pod is no longer tender enough to be cooked in this way. String beans that must be cooked from one to two hours are not worthy the name. When young enough and freshly gathered they will cook tender in twenty to forty minutes. There are a few varieties of which the pod is tender until nearly ripe. Sugar peas are cooked in the same way as string beans. After the pods are full grown they become tough, but furnish a good quality of shelled peas.

**Salted beans.**—String beans are sometimes salted for winter use. They can be kept thus for months, and during the time a bacterium is at work effecting a change somewhat similar to that brought about by the fermentation of sauerkraut. The vegetable fiber is softened and certain flavors developed by the process. Thus preserved they are a favorite winter vegetable among the Germans. Before cooking they are soaked over night to remove the salt. Shredded string beans are also dried or desiccated and are much used by armies and expeditions.

String beans and sugar peas or edible-podded peas, eaten as they are for the pod rather than the seed, fall in much the same class with spinach, cabbage, etc. They contain relatively little nourishment in proportion to their bulk and are valuable chiefly for their agreeable flavor, the salts contained in them, and the healthful variety given to the diet.

### SHELL BEANS AND GREEN PEAS.

Immature or green peas and beans freed from the pod are a highly valued article of diet in almost all countries. They contain a good proportion of proteid material and starch. The cellulose, so woody in the ripened seed, is still tender and easily cooked and the flavor is excellent. The method of preparation is very simple. They must be freshly gathered and shelled, as they deteriorate rapidly in flavor and each hour that passes after their removal from the vines increases the length of time necessary for their cooking. They should be stewed rather than boiled, the water being reduced to only enough to moisten them, and the seasoning, including a generous quantity of butter, added while the beans or peas are only half cooked. A sprig of mint added to green peas when cooking is liked by some; but it may be said in general that so delicate a flavor as that of green peas should not be covered by any strong or pungent additions. The French have a special dish, *haricots verts panaches*, or "variegated" green beans, which is a mixture of the young shelled bean with string beans.

To preserve the flavor, green beans, peas, and string beans should not be overcooked. If cooked only until tender they retain their attractive color. When overcooked they turn yellow or brownish and are much less palatable.

### CANNED BEANS AND PEAS.

Beans and peas are canned in large quantities. It would seem that the process might be improved, since much of the tastelessness of canned peas is said to be due to the fact that the water in which the peas are boiled is thrown away in the process of "blanching." Canned beans and peas are simply preserved, cooked foods having, in general, the same composition as those that come freshly cooked to the table.

### DRIED PEAS, BEANS, AND LENTILS.

Green peas and beans are often to be classed among delicacies, but we have in the ripened seed a standard food for all classes. Like the grains, they have good keeping qualities and can be combined with other materials into a variety of palatable dishes. Only fat is needed to make of beans and peas a complete food in the sense that the combination furnishes the proportion of protein, fat, and carbohydrates required by the accepted dietary standards. Hence the popular combination of beans and peas with fat meat, as pork and beans, bacon and peas, and corned beef and beans.

**Quality.**—A well-dried bean is smooth and shining; one poorly dried may be of inferior quality, with folds in the skin. The best beans are of uniform size, not too small nor a mixture of different kinds. The larger are in general preferred because they have a smaller proportion of skin, but there are several varieties of small beans that bring a high price because they have a thin skin and fine flavor. Heavy, well-filled beans bring a higher price, the weight of a bushel of different kinds varying by several pounds. The value of the dried legume depends finally on whether it will cook soft, and this is to be determined for a given lot only by putting a sample to the test. The main requirements in the cooking of dried legumes are:

(1) To so soften and disintegrate the cellulose that the nutrients that exist in close connection with it are freed.

(2) To cook the proteid constituent so as to make it digestible and palatable.

(3) To swell and burst the starch grains.

(4) To combine with various flavoring matters, as salt, pepper, fat, herbs, and butter or fat meat so that the result shall be a palatable dish.

Different specimens of beans and peas differ with regard to the ease with which they are softened in cooking. A German investigator has attributed this difference in part, at least, to the character of the soil and other conditions of growth, and believes that it may be controlled to a certain extent by the proper use of fertilizers. However, this is a point which is not definitely understood.

**Treatment of the skin.**—The first step in the ordinary household practice is the swelling and softening of the legume by soaking in water a number of hours, usually not less than eight, and the removal of such parts as will not soften by cooking. Some cooks, however, believe it is not necessary to soak the beans. They cover them with hot water and allow them to stand a short time before boiling. The first method is to be preferred.

In the ripened and dried legume the envelope becomes tough and leathery; even when cooking has done its utmost, these skins and hulls pass through the intestinal tract quite unchanged. The skin of the ripened pea and lentil is easily removed and the "split pea" and the lentil, as generally sold, have this decided advantage over the bean in the making of digestible soup and porridge. Many kinds of beans, however, after proper soaking, may be freed from their skins by stirring in water. The skins, rising to the top, are then skimmed off. The large Lima beans after soaking may easily be slipped out of the skin by pressing between the fingers. They can then be boiled and served as a vegetable of the consistency of mashed potato—sometimes called bean pudding. Peas pudding cooked in the same way is a familiar dish. In cooking beans for soup the skins may be separated by sieving.

Many housewives use soda to soften the bean skins so that they can be readily removed before baking. Snyder, at the Minnesota Experiment Station, has reported some investigations which have to do with this subject. A half teaspoonful (3 grams) of baking soda dissolved in 2 quarts of water was used to a pound of beans. When the beans were parboiled before baking some two-thirds of the water per cent of the soda were absorbed. The soda retained had probably entered into chemical combination with the proteid material of the beans. Only 0.66 per cent of the total nitrogen of the legumes was extracted by the water used for parboiling them, a loss which is unimportant. The skins removed by parboiling constituted about 6.5 per cent of the total dry matter of the beans. As shown by analysis, the skins contain a relatively small amount of protein and a fairly high percentage of crude fiber. As crude fiber is not readily digested by man the removal of a considerable proportion of it can not be considered a disadvantage. The digestibility of the skins which were removed, as well as that of the beans baked with and without parboiling, was tested by artificial methods, using ferment solutions. It was found that treatment with soda and water had a favorable effect upon the digestibility and food value of the beans, as it enabled the digestive ferments to act more readily upon the protein than was otherwise the case—that is to say, the beans thus treated were more quickly digested. The effect of soda on flavor is spoken of beyond (p. 33).

**Hard v. soft water for boiling.**—Kosutány studied the cooking of beans, especially the time required with distilled water, river water, well water, and water to which either sodium bicarbonate or magnesia had been added. As shown by the amount of water absorbed the beans cooked better in distilled water than in tap water or well water. Although the softening was influenced by the lime and magnesium content of the water, it was not found to be directly proportional to the lime content. The beans cooked more readily when soda was added to the water and less readily when magnesia was added. In general fresh beans did not cook as readily as older ones.

Strümpell in the course of his experiments on the digestibility of legumes compared the use of distilled water with that to which a certain amount of lime salts had been added. Lentils cooked in distilled water took up nearly double their own weight of water and cooked soft in one and one-half hours. Some of the same kind of lentils cooked in the hard water took up only their own weight of water and after boiling for the same length of time only the skins had swollen and lay in folds over the kernel, which remained entirely hard. Such extreme results would not follow the use of ordinary hydrant water, as it is less hard than the artificially hardened water in this case, but in proportion as it contains these salts it is unsuitable for the cooking of legumes.

The water for cooking dried legumes, it is agreed by all writers on the subject, should not be "hard" water, by which we mean impregnated with various salts, as lime and magnesia salts, since the legumin of the seeds forms with these salts insoluble compounds, with the result that portions of the vegetable remain hard, no matter how long they are cooked. Rain water is preferable for cooking legumes.

he question then arises, What is to be done when the only water ainable for cooking is hard water? In most books on cookery it advised to add to the water in which peas and beans are cooked a all quantity of baking soda, a teaspoonful to the gallon, since, if hardness is due to calcium carbonate, the soda will remedy it for oking purposes. Just why it is not easy to say. Peas and beans oked in this water are indeed easily softened, but experiment shows at the flavor may be injured. If soda is added, it is better to il the water before using. But since the cook has generally no eans of knowing the degree of hardness of the water and thus the act proportion of soda to be added, it is perhaps better to simply il the water before using and pour it from the sediment. When the rdness is due to the presence of the sulphate of lime or magnesia, ither boiling nor the addition of soda will avail to make the water sirable for cooking legumes. It is often possible to use rain water r cooking legumes, and this naturally distilled water is the very best r the purpose. The soft water should be used both for soaking and oking. As noted elsewhere (see p. 22), Richter found that peas oked in hard water were less thoroughly digested and caused more gestive disturbance than those cooked in distilled water. The ferior assimilation was attributed in part to the formation of comunds of the fat and proteids of the peas with the alkaline earth lts of the hard water which were not broken down by cooking or by e digestive juices, and in part to the salts present in the hard water.

**Flavor.**—Soaking legumes in fresh water seems also to remove a rtain bitter taste, especially noticeable in lentils, and in Eastern untries lentils are sometimes soaked for days for this purpose.

All dry legumes require a long application of heat, not only to ften the cellulose, but to develop the proper flavor; some say as ng as twelve hours. The difference of opinion on this seems due to differing estimate as to what is the desired result. The dried pea bean that has been soaked over night in water may be in one and e-half to two hours cooked soft enough to be pressed through a ve, but the tongue can still detect individual grains. To disinteate and soften absolutely every particle and to develop the best vor a much longer time is needed. The dish of pork and beans ked all night in the New England brick oven, the pea soup slowly oked for twelve hours, as in some of the special ovens which cook od very slowly, are instances of legumes properly prepared. hough the amount of protein in beans is large they contain only a all amount of fat, and hence the addition of fat in the form of lt pork or butter in preparing them for the table is reasonable, since addition to improving the flavor it makes a better balanced article diet. The flavor of dry legumes is thought by many to be improved the addition of onions and flavoring herbs or meat broth. Perps the best, as well as the most common, method of preparing the dried pea and lentil is in a thick soup or purée seasoned with pepper, and butter. Beans are also often cooked in this way, alth perhaps more frequently served in the United States as baked b

### BAKED BEANS, PEAS, AND COWPEAS.

After a preliminary boiling, beans, peas, and cowpeas may be b in an oven, with various additions thought to improve the flavo pork, molasses, etc. The small white or navy bean is quite gener used for this purpose, chiefly because its skin is thin and tender, the mode is well adapted to all varieties of beans. It is gener thought that the fat present in such dishes improves their flavor.

### ROASTING.

While roasting is almost the only method in use among us in preparation of the peanut, it is perhaps never applied in the Uni States to the other legumes. The pea and the lentil are roasted the Mediterranean countries and form there a regular article of fo In India peas are parched in hot sand. For a people who pos only primitive cooking appliances, roasting certainly has the adv tage over boiling. Just as a quantity of peanuts may be roasted w a handful of charcoal, while at least two hours of stewing are nee to soften them, so the chick-pea, as found by experiment, can parched over coals in a few moments and thus made edible. taste reminds one of pop corn and roasted chestnuts. A slight terness is present, due, probably, to the skin, which does not off in roasting, as does the skin of peanuts. When this ski removed before roasting, as it may be by a half hour's soaking, product is improved.

Although these roasted legumes may not be needed as an add to our bill of fare, it is easy to see how valuable they may be t Arab who toils over arid plains or to the native of India i mountain journeys.

Our common split pea is also palatable when parched. Pa peas are too hard for any but the strongest teeth, and, as us India, they are ground and cooked after parching. The r chick-pea is also used as a substitute for coffee. The roasted p is spoken of later.

### PEA AND BEAN FLOUR.

Since it has been shown by such investigations as those of S pell that the legumes when ground into flour and cooked in so baked in cakes are much more completely digested than when c whole, it would seem that bean, pea, and lentil flour, as such, be common in the market. It is, however, offered only in small ages mixed with the flour of grains and sold under various names as a nutritious and digestible food, especially recomm r invalids. In preparations for the market it has been cooked for ong time under pressure.

In certain countries of Europe a proportion of bean flour is mixed th wheat flour for bread making, especially with wheat which has ow percentage of gluten or that in which the gluten has deteri- ated in quality because of the sprouting of the grain in wet seasons. such cases an addition of 2 to 4 per cent is thought to improve bread, and 2 per cent, if stamped on the package, is allowed by .

## SOUP TABLETS AND PEA SAUSAGE.

Finely ground peas, beans, and lentils form the basis of many soup lets, and condensed foods used extensively by armies, explorers, . The best known is the "pea sausage," which did such good vice for the German troops in the Franco-Prussian war. It was ented by a cook, and the German Government bought the secret its preparation. It consists of pea and lentil flour well cooked, porated and mixed with a proportion of bacon, the proper sea- ings, and some preservative. Mixed with hot water, it made a y nutritious soup for the soldier. It was found by the German ny to be invaluable, if used only in emergencies, but its continuous brought on digestive disturbances and the eater soon tired of its te.

## PEANUTS AND PEANUT PREPARATIONS.

Of the 4,000,000 bushels of peanuts raised annually in this country 00,000 bushels are used roasted. The remainder of the crop and peanuts of an inferior grade go to the confectioner and appear in nut candy and other confections. Therefore at present the peanut, used among us, is hardly to be considered a food, but, as already id, only as a food accessory or luxury. It is quite possible, how- er, that this highly nutritious and cheap product of our Southern elds may come to be used in more ways than it is at present, and specially in combination with other food materials.

**Peanut butter.**—The roasted peanut ground into an oily meal has omewhat the consistency of butter and is now marketed under the ame of peanut butter. Salt is perhaps quite generally added during he process of manufacture. Water is also sometimes added—usually efore serving. Peanut butter is used like other butter to spread on read, for the making of sandwiches, and in the preparation of a num- er of made dishes. Many persons like its flavor when it is fresh and f good quality, and it seems fair to say that the use of this and other rts of nut butter is growing. As regards composition, peanut but- r, which is essentially the ground roasted peanut, contains more pro- in and less fat than ordinary butter. Little is known regarding the igestibility of peanut butter, but the fine grinding would naturally em to be of an advantage. Judged by Jaffa's experiments with a tion containing peanuts, it would be well digested. (See p. 26.)

**Peanut oil.**—At present the American peanut crop is not
enough to more than supply the roaster and the confectioner,
the expressing of oil from the peanut has never become establ
here, but in Europe large quantities of the African-raised nu
used for this purpose. The shelled nuts contain from 30 to 50 pe
of oil. The oil is said to be of fairly good flavor, but inferi
olive oil. In 1899 some 80,000 tons of the nuts were used in Ma
alone for oil making. The unhusked nuts are passed between
of rapidly revolving grooved rollers and the shells and red inne
are then removed by a winnowing process with the use of air cu
and oscillating sieves. The cleaned kernels are ground an
enveloped in fibrous mats and pressed to extract the oil.

According to Brannt, "the first cold pressure yields 16 to
cent of very fine table oil. The residue is then broken up, mo
with water, and again cold pressed, yielding 7 to 8 per cent of a
less valuable oil, used for table purposes and burning. The
from this is heated and then pressed, giving 7 to 8 per cent m
unfit for table use, but used for soap and lubricating." Th
grades of oil are sold as salad oil alone or mixed with olive oil.

**Peanut cake.**—When the oil has been pressed from the groun
nut, the mass remaining, called oil cake, is used for fattening
Some experiments have also been made as to its food value for
beings. Containing, as it does, 47 per cent of protein and 9 p
of fat and starch, and costing about 5 cents a pound, thi
attracted the attention of German scientists. The oil cak
broken up and cooked a long time in water and eaten as a s
porridge in a hospital. Most of those who tried it ate it with
ent relish, not once only, but again and again. No effort se
have been made to ascertain to what extent it was digested, a
use of the cake does not seem to have passed the experimental s

## COMPARATIVE VALUE OF LEGUMES IN RELATION TO THEIR

The legumes have been spoken of as economical foods. The ta
page 37 shows the nutrients and energy furnished by 10 cents'
of the different fresh, dried, and canned legumes commonly ea
the United States. For purposes of comparison similar valu
included for some of the common animal and vegetable foods.
cases the values are calculated on the basis of the composition
food materials as purchased, and include the usual amounts of in
material (pods, bones, etc.). The prices selected per pound ar
essarily somewhat arbitrary. They are, however, based on
market conditions found in dietary studies and other investig
and are believed to represent a fair range of prices. The leg
although staple foods, have not yet attained the importance
cereal grains, and therefore vary more in price.

3.—*Nutrients furnished for 10 cents in legumes and other food materials at certain prices per pound.*

| od materials as purchased. | Prices per pound. | Ten cents will pay for— Total food material. | Protein. | Fat. | Carbo-hydrates. | Fuel value. |
|---|---|---|---|---|---|---|
| | *Cents.* | *Pounds.* | *Pounds.* | *Pound.* | *Pounds.* | *Calories.* |
| beans, dried | 5 | 2.00 | 0.45 | 0.04 | 1.19 | 3,210 |
| s, dried | 4 | 2.50 | .55 | .03 | 1.63 | 4,190 |
| eans, fresh, in pod | 3 | 3.33 | .11 | .01 | .33 | 850 |
| | 4 | 2.50 | .08 | .01 | .25 | 640 |
| eans, fresh, shelled | 6 | 1.67 | .05 | .01 | .17 | 425 |
| | 8 | 1.25 | .04 | | .12 | 320 |
| eans, canned | 6 | 1.67 | .07 | .01 | .24 | 600 |
| ean-, dried | 4 | 2.50 | .45 | .04 | 1.65 | 4,065 |
| | 6 | 1.67 | .30 | .03 | 1.10 | 2,715 |
| beans, fresh, 20 cents per peck | 2 | 5.00 | .11 | .02 | .35 | 900 |
| beans, fresh, 30 cents per peck | 3 | 3.33 | .07 | .01 | .23 | 600 |
| baked, canned | 3 | 3.33 | .23 | .08 | .65 | 2,000 |
| | 5 | 2.00 | .14 | .05 | .39 | 1,200 |
| , dried | 10 | 1.00 | .26 | .01 | .59 | 1,620 |
| | 6 | 1.67 | .43 | .02 | .99 | 2,705 |
| reen, in pod, 20 cents per peck | 2 | 5.00 | .18 | .01 | .49 | 1,275 |
| reen, in pod, 30 cents per peck | 3 | 3.33 | .12 | .01 | .33 | 850 |
| anned | 5 | 2.00 | .07 | | .20 | 510 |
| | 7 | 1.43 | .05 | | .14 | 365 |
| ried | 3 | 3.33 | .82 | .03 | 2.06 | 5,510 |
| | 4 | 2.50 | .62 | .03 | 1.55 | 4,140 |
| | 5 | 2.00 | .49 | .02 | 1.24 | 3,310 |
| as, green, shelled | 5 | 2.00 | .19 | .01 | .45 | 1,240 |
| as, dried | 2 | 5.00 | 1.07 | .07 | 3.04 | 7,950 |
| flour | 2 | 5.00 | .57 | .05 | 3.76 | 8,250 |
| | 2.5 | 4.00 | .46 | .04 | 3.00 | 6,600 |
| | 3 | 3.33 | .38 | .03 | 2.50 | 5,495 |
| bread | 3 | 3.33 | .31 | .04 | 1.77 | 4,045 |
| | 5 | 2.00 | .18 | .03 | 1.06 | 2,430 |
| | 8 | 1.25 | .12 | .02 | .66 | 1,520 |
| eal | 2 | 5.00 | .46 | .10 | 3.77 | 8,275 |
| | 3 | 3.33 | .31 | .06 | 2.51 | 5,510 |
| al | 3 | 3.33 | .54 | .24 | 2.25 | 6,195 |
| | 5 | 2.00 | .32 | .14 | 1.35 | 3,720 |
| | 6 | 1.67 | .13 | .01 | 1.32 | 2,720 |
| | 8 | 1.25 | .10 | | .99 | 2,040 |
| es, 45 cents per bushel | 0.75 | 13.33 | .24 | .01 | 1.96 | 4,130 |
| es, 60 cents per bushel | 1 | 10.00 | .18 | .01 | 1.47 | 3,100 |
| es, 90 cents per bushel | 1.5 | 6.67 | .12 | .01 | .98 | 2,070 |
| ge | 4 | 2.50 | .04 | .01 | .12 | 315 |
| | 5 | 2.00 | .03 | | .10 | 250 |
| irloin | 10 | 1.00 | .16 | .18 | | 1,040 |
| | 15 | .66 | .11 | .12 | | 685 |
| | 20 | .50 | .08 | .09 | | 520 |
| | 25 | .40 | .06 | .07 | | 415 |
| ound | 8 | 1.25 | .24 | .16 | | 1,120 |
| | 12 | .83 | .16 | .11 | | 745 |
| | 16 | .63 | .12 | .08 | | 565 |
| moked | 10 | 1.00 | .14 | .33 | | 1,675 |
| | 16 | .63 | .09 | .21 | | 1,055 |
| | 22 | .46 | .07 | .15 | | 770 |
| rk | 12 | .83 | .02 | .72 | | 3,045 |
| , fresh | 6 | 1.67 | .14 | | | 275 |
| | 10 | 1.00 | .08 | | | 165 |
| , dried, salt | 6 | 1.67 | .27 | .04 | | 525 |
| | 8 | 1.25 | .20 | .01 | | 395 |
| 5 cents per dozen | 10 | 1.00 | .13 | .09 | | 635 |
| 5 cents per dozen | 16.7 | .60 | .08 | .05 | | 380 |
| 5 cents per dozen | 23.3 | .43 | .06 | .04 | | 275 |
| cents per quart | 1.5 | 6.67 | .22 | .27 | .33 | 2,170 |
| cents per quart | 3 | 3.33 | .11 | .13 | .17 | 1,080 |
| cents per quart | 4 | 2.50 | .08 | .10 | .13 | 815 |
| , whole milk | 12 | .83 | .22 | .28 | .02 | 1,620 |
| | 16 | .63 | .16 | .21 | .02 | 1,230 |

will be seen that at the prices selected the dried legumes furnish protein and energy than almost any food material except cereal s, while the fresh legumes are directly comparable with our most itious green vegetables. Dried cowpeas at the price noted above furnish more protein and energy per pound than any other legumes and almost twice as much protein and nearly the same amount of energy as wheat flour at 2 cents per pound. Dried kidney beans at 5 cents per pound supply about the same protein and half as much energy as wheat flour at 2.5 cents per pound. The facts brought out in the above table show the importance of legumes when considered from the standpoint of pecuniary economy and go to prove that they may profitably be used to a considerable extent as a source of protein when the diet is deficient in this constituent and the income is limited.

## SUMMARY.

The green or immature pea and bean are among our most valuable green vegetables and fully deserve the place they now hold on our bill of fare. The value of the dried pea, bean, and lentil is such that one or more representatives are found in every country as a staple food, and they have been thus used from the earliest times. They are especially rich in protein, the nitrogenous constituent which forms the chief nutrient of meat, and are thus fitted to take the place of part of the meat in the dietary. Since in comparison with their value their price is low, they must be considered among vegetable foods as next in importance to bread. As compared with the cereals the legumes are (1) less completely digested if eaten in considerable quantities; (2) it is improbable that they can be made into any form of palatable bread, and (3) their flavor is less generally liked, and on that account they will seldom be made a regular daily food except by people who are forced to it by necessity.

As an occasional food, dried legumes are used in perhaps the majority of American families. Properly combined with other foods they form a palatable addition to the diet and help to give variety to the menu. In view of their low cost and high nutritive value and wholesomeness, they may profitably be used even to a greater extent than they are at present.

Care in the preparation of legumes is very important both as regards their digestibility and their flavor.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

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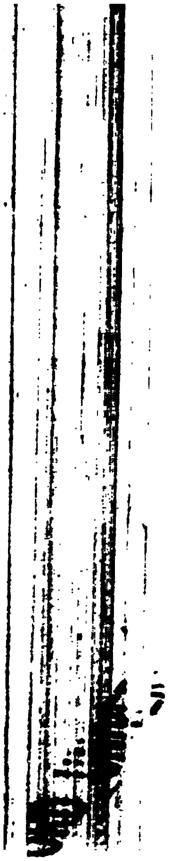

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U. S. DEPARTMENT OF AGRICULTURE.

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FARMERS' BULLETIN No. 128.

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# GS AND THEIR USES AS FOOD.

BY

C. F. LANGWORTHY, Ph. D.

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[Revised November 10, 1906.]

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PREPARED UNDER THE SUPERVISION OF THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

# LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
*Washington, D. C., November 10, 1906.*

Sir: I have the honor to transmit herewith an article on eggs and their uses as food, prepared by C. F. Langworthy, chief of nutrition investigations of this Office, in accordance with instructions given by the Director of this Office.

This Department has in the past published a number of popular bulletins which summarized the available information on different food materials which enter largely into the diet of most families. The present bulletin is similar in purpose to those published earlier.

The agricultural experiment stations in a number of States have studied problems connected with the production or composition of eggs, or some other related topic, and in so far as possible the results of their work have been drawn upon.

In preparing this bulletin Doctor Langworthy has made an extended study of the literature of the subject, and has endeavored to present such data as are of general interest rather than more technical matter.

Mention should be made of the assistance rendered by Miss Elizabeth C. Sprague, of the household science department of the University of Illinois. Thanks are due to Miss Sprague for the use of unpublished data and many suggestions, and also to Miss Isabel Bevier, professor of household science at the University of Illinois.

In preparing the revision of this bulletin some changes have been made, and material which has accumulated since it was first published has been added.

It is believed that the article is a useful summary of available information on the subject, and its publication as a Farmers' Bulletin is therefore recommended.

Respectfully,
A. C. True,
*Director.*

Hon. James Wilson,
*Secretary of Agriculture.*

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# EGGS AND THEIR USES AS FOOD.

## INTRODUCTION.

Perhaps no article of diet of animal origin is more commonly eaten in all countries or served in a greater variety of ways than eggs. Hens' eggs are most common, altho the eggs of ducks, geese, and guinea fowls are used to a greater or less extent, guinea eggs being prized for their delicate flavor. More rarely turkeys' eggs are eaten, but they are generally of greater value for hatching. In South Africa, where ostrich raising is an important industry, the eggs are used as food to some extent and are said to be of excellent quality for cookery. Their food value is also recognized in those regions in the United States where ostriches are raised.

The eggs of some wild birds are esteemed a delicacy. Plover eggs are prized in England and Germany, while in this country the eggs of sea birds have long been gathered for food. On the eastern shore of Virginia eggs of the laughing gull are frequently eaten, and the eggs of gulls, terns, and herons were a few years ago gathered in great quantities along the coast of Texas. Thousands of eggs of gulls and murres have been gathered annually on the Farallone Islands, off the coast of California.[a]

Other eggs besides those of birds are sometimes eaten. Turtle eggs are highly prized in most countries where they are abundant. They were once more commonly eaten in America than now, possibly owing to the more abundant supply in former times. The eggs of the terrapin are usually served with the flesh in some of the ways of preparing it for the table. Fish eggs, especially those of the sturgeon, are eaten in large quantities, preserved with salt, under the name of caviar. Shad roe is also a familiar example of the use of fish eggs as food. Mention may also be made of the use of the eggs of alligators, lizards, serpents, and some insects by races who lack the prejudices of Western nations. However, in general, the term eggs, when used in connection with food topics, refers to the eggs of birds, usually domestic poultry, and is so used in this bulletin.

The appearance of an egg—the shell with its lining of membrane, inclosing the white and yolk—is too familiar to need any discussion. The physiological structure of the egg is perhaps less familiar. A fertile egg contains an embryo and is at the same time a storehouse of material for the development and growth of the young individual from the embryo, until it has reached such a stage that life is possible outside the narrow limits of the shell. The embryo is situated quite close to the yolk, which furnishes the nutritive material for its early development, the white being used later.

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[a] The danger of exterminating these desirable birds by gathering their eggs for food has been discust in the U. S. Dept. Agr. Yearbook 1899, p. 270.

For convenience, birds may be divided into two groups: (1) Those in which the young are hatched full-fledged and ready in a great measure to care for themselves, and (2) those in which the young are hatched unfledged and entirely dependent upon the parents for some time. Domestic poultry are familiar examples of the first group; robins and sparrows of the second. The eggs of the two classes differ materially in composition. It seems evident that more nutritive material is needed proportionally in the first case than in the second, since the growth is continued in the egg until the bird reaches a more advanced stage of development. The quite marked differences in composition of the two sorts of eggs have been shown by chemical studies, but need not be referred to further in the present discussion.

Since in all cases the egg is designed to furnish the sole source of material for growth and development of the young individual for a considerable time, it is evident that it must contain all the elements required; that is, that it must be a perfect food for the purpose intended. Milk is another familiar example of animal food containing all the elements of a complete food for the young and growing individual. Milk and eggs are frequently spoken of as perfect foods on this account. The designation is, however, misleading, for altho it is true that they contain all the required elements for the growth and maintenance of the young bird or the young mammal, as the case may be, the elements are not in the right proportion for the sole nourishment of an adult individual. The food value of eggs is discust in greater detail beyond.

## COOKING AND SERVING EGGS.

The methods of serving eggs alone or in combination with other food materials are very numerous. Cooked in various ways they are a favorite animal food, taking the place of meat to a certain extent, while raw eggs, usually seasoned in some way, are by no means infrequently eaten. Boiled eggs are often used for garnishing or ornamenting different foods. Eggs are combined with other materials in various ways in many made dishes. They are used in making cakes and such foods to improve their flavor, color, and texture, while in custards, creams, etc., they thicken the material and give it the desired consistency. The white of the egg is also employed in making icings and confectionery. Well-beaten or whipped egg white is used to leaven many forms of cakes and similar foods, as well as to improve the flavor. The beaten white incloses air in small bubbles, which become distributed thruout the mass of dough in mixing. The heat of cooking expands the air and makes the walls of the air bubbles firm, so that the porous structure is retained. The power to inclose and retain air when beaten varies, being greatest in the fresh egg and much lessened in packed or old eggs. Convenient leavening powders have lessened the number of eggs used for this purpose. Sponge cake, however, is a familiar example of food so leavened. This use of eggs explains some of the recipes in old cookery books which call for such large numbers of eggs. These uses are all familiar; the reasons for them are doubtless seldom thought of.

There are several simple ways of cooking eggs which are very commonly followed. Thus, the egg in the shell is cooked by immersion in hot or boiling water or is less commonly roasted. After removal from the shell, the egg is cooked in hot water or in hot fat. In the latter case it may or may not be beaten or stirred. Combined with other materials to form various made dishes, eggs are boiled, baked, steamed, or fried, as the case may be. The total number of methods of serving and preparing eggs is very large, but in nearly every case it will be found that the method of preparation is only a more or less elaborate modification of one of the simple methods of cooking.

Changes in weight, which are dependent on the methods of cooking, are commonly noted when foods are prepared for the table, losses in weight being due in general to the volatilization and gains to the absorption of water. Carpiaux found that when eggs were cooked for an hour in a steam bath the loss in weight was insignificant, ranging from 0.03 to 0.1 gram per egg. Camus found that with boiled eggs there was more or less loss, owing to evaporation of a little water thru the porous shell. If the egg cooled in the water, it absorbed a little of it and gained in weight. The method of manipulation must have some effect on the changes in weight, for Lebbin reports that boiled eggs gained on an average about 0.5 gram, probably because a little water past thru the shell. From the tests as a whole it is evident that the changes in weight in all cases are small and not sufficient to modify the food value to any appreciable extent.

When cooked in different ways there are marked changes in the appearance and structure of eggs. As ordinarily applied, the term "boiled eggs" refers to eggs cooked in the shell in hot, tho not necessarily boiling, water. The resulting product varies greatly, according to the length of time the cooking is continued, the method of procedure, etc. Perhaps the most usual household method of "boiling eggs" is to immerse them for a longer or shorter time in boiling water. An egg placed in boiling water not over 2 minutes will have a thin coating of coagulated white next the skin, the remainder will be milky, but not solid, while the yolk, tho warm, will be entirely fluid. This stage may be called "very soft boiled." If the egg is kept in boiling water 2 minutes, or a little over, the white becomes entirely coagulated. The egg thus cooked may be termed "waxy." If the boiling is extended to 3 minutes or so, the egg shows a tendency to rise in the water and will be solid thruout, i. e., "solid boiled." If the boiling is continued up to 10 minutes or longer, the "hard-boiled" egg results. The white of such an egg is hard and elastic and the yolk crumbles readily. All these changes are due principally to the more or less complete coagulation and hardening of the albumen of the egg by heat.

Numerous experiments have been made to show the changes which actually take place when egg albumen is heated. If the egg white is gently warmed, no change is noticed until the temperature reaches 134° F., when coagulation begins. White fibers appear, which become more numerous, until at about 160° F. the whole mass is coagulated, the white almost opaque, yet it is tender and jelly-like. If the temperature is raised to 212° F. (the temperature of boiling water) and continued, the coagulated albumen becomes much harder and eventually more or less tough and horn-like; it also undergoes shrinkage. When the whole egg is cooked in boiling water, the temperature of the interior does not immediately reach 212° F., several minutes being probably required. It has been found by experiment that the yolk of egg coagulates firmly at a lower temperature than the white.

The changes in the albumen noted above suggest the idea that it is not desirable to cook eggs in boiling water in order to secure the most satisfactory product. Those who have given attention to the science as well as the practise of cookery recommend "soft-cooked," "medium-cooked," and "hard-cooked" eggs, all of which are cooked at a temperature lower than 212° F. In soft-cooked eggs, properly prepared, the white resembles a soft, thick curd, while the yolk is fluid. Except for a suggestion of rawness, there will be little flavor, provided fresh eggs are used. Medium-cooked eggs are more thoroly cooked than those just mentioned, the results being secured by longer cooking or by a somewhat higher temperature. The white is soft and tender and the yoke slightly thickened. The flavor (which is developed by cooking) is more pronounced than that of a soft-cooked egg and is generally considered more agreeable.

When an egg is covered with boiling water in a bain-marie or double boiler, and the temperature of the water in the outer vessel maintained at 180–190° F. for 30 to 45 minutes, the hard-cooked egg results, with the yolk dry and mealy and the white solid, yet tender.

The directions given for preparing soft-cooked, medium-cooked, and hard-cooked eggs vary. The methods described in standard cookery books without doubt give the desired results if sufficient care is exercised. The chief difficulty encountered by most cooks is to secure uniform results, especially with soft-cooked and medium-cooked eggs. It must be remembered that such results can not be expected when conditions vary. The time of cooking, the amount of water used, the number, size, and freshness of the eggs, and the kinds of vessels used are important factors. Thus, eggs which have been kept in an ice chest require more heat to warm them before cooking begins than do those which have been kept at room temperature. Again, so apparently trivial a detail as the sort of vessel used (whether earthen or metal) or the place where the vessel stands during cooking may produce very different results. Many persons prefer to have eggs cooked at table in a chafing dish or other suitable vessel. In such cases the conditions may be controlled with comparative ease and uniform results obtained with a little practise if care is observed.

The following methods of preparing soft-cooked and medium-cooked eggs have been found to give uniform results in laboratory tests at the University of Illinois: Using a granite-ware stewpan of 1 quart capacity, 1 pint of water was heated over a gas flame; when the water boiled the gas was turned off and an egg which had been kept in a refrigerator was dropt into the water. Without disturbing the vessel it was covered closely and the egg allowed to remain in the water 6 minutes. It was then soft cooked. As shown by tests, when the egg was dropt into the water the temperature fell almost at once to 185° F. and then slowly to 170–171° F. If the egg remained in the water 8 minutes, it was medium cooked, the temperature of the water at the end of the period having fallen to 162–164° F.

Uniform results can be obtained in the kitchen as well as in the laboratory if sufficient attention is given to details. Bearing clearly in mind the end desired, each cook must experiment for herself, as it is impossible to give directions which will apply to all cases.

The same changes which have been noted above as taking place in egg yolk and white when heat is applied in preparing boiled eggs take place when other methods of cooking are followed, tho they are not always apparent.

Poached or dropt eggs are removed from the shell and then cooked in water. Thudichum recommends the use of salted water to which a very little vinegar has been added. The reason for this is perhaps that acetic acid (vinegar) tends to precipitate albumen—that is, to prevent a loss due to some of the egg being dissolved in the water. Flavor may also be one of the objects sought.

Fried eggs are generally cooked in a flat pan, in a little hot fat, oil, or butter, and may be either soft or hard, according to the length of time employed in the process. Eggs are also occasionally baked in much the same manner that they are fried.

The omelet is generally regarded as one of the most appetizing forms in which eggs can be served. It consists of the beaten egg with a little milk, water, and cream or melted butter added, quickly cooked in a little fat or butter in a suitable pan, and folded over so that it may be turned out of the pan in a half-round form. Some cooks insist that the best omelets are made by using hot water instead of milk or cream. The hot water is stirred into the egg yolk in the proportion of 1 tablespoonful to an egg. Scrambled eggs resemble an omelet in method of preparation, but no effort is made to preserve the characteristic form and appearance of the omelet. Generally speaking, lightness is desired in an omelet and thoro mixing in scrambled eggs. The former is secured by beating; the latter by stirring. Omelets are sometimes made with the addition of various materials, such as parsley, jams, etc. Many so-called omelets are made in which flour is used. These are more properly pancakes, and vary very greatly according to the ingredients used. Such dishes, as well as sweet omelets, etc., are treated of in cookery books, as are also many other ways of serving eggs, which are in principle the same as those already noted, but in which the final appearance is more or less modified.

The foods in which eggs are combined with other materials range from a simple custard or cake to the most elaborate of the confectioner's products. In all such dishes, as previously noted, eggs are used to give consistency, color, flavor, or lightness.

Eggs are especially rich in protein (the nitrogenous ingredient of food). This material is required by man to build and repair the tissues of the body. Some energy is also furnished by protein, but fats and carbohydrates supply the greater part of the total amount needed. Combining eggs with flour and sugar (carbohydrates) and butter, cream, etc. (fat), is perhaps an unconscious effort to prepare a food which shall more nearly meet the requirements of the body than either ingredient alone. When eggs, meat, fish, cheese, or other similar foods rich in protein are eaten, such other foods as bread, butter, potatoes, etc., are usually served at the same time, the object being, even if the fact is not realized, to combine the different classes of nutrients into a suitable diet. The wisdom of such combination as well as of other generally accepted food habits, was proved long ago by practical experience. The reason has been more slowly learned.

As previously stated, egg white when heated at the temperature of boiling water for a considerable time becomes hard and contracts. This explains the curdling of custards, shrinkage and toughening of omelets, soufflés, meringues, sponge cake, and similar mixtures. The firm coagulation of albumen at 212° F. explains the use of egg white for clarifying coffee, soup, or other liquids. The albumen, which is mixed with the liquid before boiling coagulates and incloses the floating particles, leaving the liquor clear. When eggs are removed from the shell, a little of the white usually clings to the inner surface unless it is scraped. Such eggshells are often used for clarifying purposes instead of the whole egg. The clarifying properties are, of course, due to the egg white and not to the shells.

The uses of eggs for other purposes than food are numerous. Large quantities of egg white are used in the manufacture of albumen paper for photographic purposes, and the egg white and yolk, and products made from them, are very important in the manufacture of many different articles.

## DESCRIPTION AND COMPOSITION OF EGGS.

**Size.**—The eggs of different kinds of domestic poultry vary in size as well as appearance, and there is also a considerable range in the size of eggs of different breeds; thus, hens' eggs range from the small ones laid by bantams to the large ones laid by such breeds as Light Brahmas. On an average a hen's egg is 2.27 inches in length and 1.72 inches in diameter or width at the broadest point, and weighs about 2 ounces, or 8 eggs to the pound (1.5 pounds per dozen). Generally speaking, the eggs of pullets are smaller than those of old hens, those of ducks somewhat larger than hens' eggs, while those of turkeys and geese are considerably larger. Guinea eggs, on an average, measure 1.87 by 1.5 inches, are rather pointed at one end, and weigh about 1.4 ounces each, or 17 ounces to the dozen. Goose eggs weigh about 5.5 to 6.7 ounces each, or about 5 pounds to the dozen—that is, more than three times as much as hens' eggs. The eggs of wild birds are said to be smaller than those of the same species when domesticated. Wild ducks' eggs are said to be, on an average, 1.97 to 2.17 inches in diameter, and domestic ducks' eggs 2.36 to 2.56 inches.

**Composition.**—The shells of hens' eggs constitute about 11 per cent, the yolk 32 per cent, and the white 57 per cent of the total weight of the egg. The proportion of white and yolk varies somewhat with different breeds. According to recent investigations the proportion of yolk is greatest in bantam eggs, and in general is greater with breeds of poultry which are best suited for fattening than with breeds. As shown by tests made at the New York State Experi Station, white-shelled eggs have a somewhat heavier shell than br shelled eggs. The shell of a duck's egg constitutes about 14 per of the total weight, and that of a plover egg 10 per cent. The fol ing table shows the composition of hens' eggs, raw and cooked, br shelled and white shelled, and of egg white and yolk, as well as composition of the egg (whole egg white and yolk) of the gu fowl, duck, goose, turkey, plover, etc., also evaporated eggs and substitutes. For purpose of comparison, the composition of beefs and several other familiar animal foods and of wheat flour potatoes, is also added.

*Average composition of eggs, egg products, and certain other foods.*

| | Refuse. | Water. | Protein. | Fat. | Carbohydrates. | Ash. |
|---|---|---|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Hen: | | | | | | |
| Whole egg as purchased | 11.2 | 65.5 | 11.9 | 9.3 | .......... | 0.9 |
| Whole egg, edible portion | .......... | 73.7 | 13.4 | 10.5 | .......... | 1.0 |
| White | .......... | 86.2 | 12.3 | .2 | .......... | .6 |
| Yolk | .......... | 49.5 | 15.7 | 33.3 | .......... | 1.1 |
| Whole egg boiled, edible portion | .......... | 73.3 | 13.2 | 12.0 | .......... | .8 |
| White-shelled eggs as purchased | 10.7 | 65.6 | 11.8 | 10.8 | .......... | .6 |
| Brown-shelled eggs as purchased | 10.9 | 64.8 | 11.9 | 11.2 | .......... | .7 |
| Duck: | | | | | | |
| Whole egg as purchased | 13.7 | 60.8 | 12.1 | 12.5 | .......... | .8 |
| Whole egg, edible portion | .......... | 70.5 | 13.3 | 14.5 | .......... | 1.0 |
| White | .......... | 87.0 | 11.1 | .03 | .......... | .8 |
| Yolk | .......... | 45.8 | 16.8 | 36.2 | .......... | 1.2 |
| Goose: | | | | | | |
| Whole egg as purchased | 14.2 | 59.7 | 12.9 | 12.3 | .......... | .9 |
| Whole egg, edible portion | .......... | 69.5 | 13.8 | 14.4 | .......... | 1.0 |
| White | .......... | 86.3 | 11.6 | .02 | .......... | .8 |
| Yolk | .......... | 44.1 | 17.3 | 36.2 | .......... | 1.3 |
| Turkey: | | | | | | |
| Whole egg as purchased | 13.8 | 63.5 | 12.2 | 9.7 | .......... | .8 |
| Whole egg, edible portion | .......... | 73.7 | 13.4 | 11.2 | .......... | .9 |
| White | .......... | 86.7 | 11.5 | .03 | .......... | .8 |
| Yolk | .......... | 48.3 | 17.4 | 32.9 | .......... | 1.2 |
| Guinea fowl: | | | | | | |
| Whole egg as purchased | 16.9 | 60.5 | 11.9 | 9.9 | .......... | .8 |
| Whole egg, edible portion | .......... | 72.8 | 13.5 | 12.0 | .......... | .9 |
| White | .......... | 86.6 | 11.6 | .03 | .......... | .8 |
| Yolk | .......... | 49.7 | 16.7 | 31.8 | .......... | 1.2 |
| Plover: | | | | | | |
| Whole egg as purchased [a] | 9.6 | 67.3 | 9.7 | 10.6 | .......... | .9 |
| Whole egg, edible portion [a] | .......... | 74.4 | 10.7 | 11.7 | .......... | 1.0 |
| Fresh-water turtle eggs [a] | .......... | 65. | 18.1 | 11.1 | .......... | 2.9 |
| Sea-turtle eggs [a] | .......... | 76.4 | 18.8 | 9.8 | .......... | .4 |
| Salted duck eggs [a] | .......... | 68.0 | 12.0 | 9.2 | .......... | 4.6 |
| Evaporated hens' eggs: | | | | | | |
| Whole egg | .......... | 6.4 | 46.9 | 36.0 | 7.1 | 3.6 |
| White [a] | .......... | 11.7 | 73.2 | .3 | 8.6 | 6.2 |
| Yolk | .......... | 5.9 | 33.3 | 51.6 | 5.7 | 3.5 |
| Egg substitute | .......... | 11.4 | 73.9 | .3 | 5.3 | 9.1 |
| Pudding (custard) powder [a] | .......... | 13.0 | 2.1 | 3.4 | 80.9 | .6 |
| Cheese as purchased | .......... | 34.2 | 25.9 | 33.7 | 2.4 | 3.8 |
| Sirloin steak as purchased | 12.8 | 54.0 | 16.5 | 16.1 | .......... | .7 |
| Sirloin steak, edible portion | .......... | 61.9 | 18.9 | 18.5 | .......... | 1.0 |
| Milk | .......... | 87.0 | 3.3 | 4.0 | 5.0 | .7 |
| Oysters in shell as purchased | 81.4 | 16.1 | 1.2 | .2 | .7 | .4 |
| Oysters, edible portion | .......... | 86.9 | 6.2 | 1.2 | 3.7 | 2.0 |
| Wheat flour | .......... | 12.0 | 11.4 | 1.0 | 75.1 | .5 |
| Potatoes as purchased | 20.0 | 62.6 | 1.8 | .1 | 14.7 | .8 |
| Potatoes, edible portion | .......... | 78.3 | 2.2 | .1 | 18.4 | 1.0 |

[a] European analyses.

The above figures represent average values. Individual specimens y more or less from the average.

s is shown by analysis, eggs consist chiefly of two nutrients—tein and fat—in addition to water and mineral matter or ash. bohydrates are present in small amounts and are usually not ermined in analyses. According to recent figures, duck eggs con- 0.3 per cent, hens' eggs 0.67 per cent, turkey and guinea eggs 0.8 per cent, and goose eggs 1.3 per cent of carbohydrates. ver eggs contain considerably more, the amount reported being 2 per cent. In the case of domestic poultry about one-third of carbohydrates occurs in the yolk and about two-thirds in the te of the egg. The protein or nitrogenous matter is the nutrient ch is needed to build and repair body tissue, as already stated, le the fat is useful for supplying energy. Some energy is also ved from protein. Mineral matter is required by the body for ding bones and other tissue and for other purposes, but less is itely known concerning the kind and amount required than in case of the other constituents.

composition, eggs of all sorts resemble such animal foods as t, milk, and cheese, more than such vegetable foods as flour and toes. As will be seen by the figures in the above table, hens' s and those of other domestic fowls do not differ greatly in com- tion. Neither does the cooked egg vary materially in composi- from the raw, tho it varies markedly in texture. The yolk and te differ greatly in composition. The yolk contains considerable and ash, while the white is practically free from fat and has a small ash content. The white contains somewhat less protein about twice as much water as the yolk. As is usually the case h our familiar foods, the water is not visible as such, but is com- ed or mingled with the other constituents, so that the whole food nore or less moist, liquid, or juicy.

The figures quoted in the table show that there is practically no ference in composition between hens' eggs with dark shells and ose with white shells, altho there is a popular belief in some locali- s that the former are "richer."

As shown by their composition, eggs are nutritious food. They less concentrated—i. e., contain more water—than cheese, but are re concentrated than milk or oysters. In water content they do differ greatly from the average value for lean meat. The kinds amounts of nutrients in eggs indicate that they may be properly d in the diet in the same way as most other animal foods, and this ief is confirmed by the experience of uncounted generations.

The table shows the nutrients in different kinds of eggs and in a other foods. Many studies have been made of the chemical bodies making up the different classes of nutrients. Egg white is sometimes said to be pure albumen. In reality it consists of several albumens, and, according to many observers, a little carbohydrate material. The phosphorus in the albumen of the egg white is equivalent to about 0.03 per cent phosphoric acid. The chief ash constituent is sodium chlorid (common salt).

A very extended investigation of the white of egg was made at the Connecticut State Experiment Station. The "albumen" or protein of egg white was found to consist of four bodies—ovalbumen, conalbumen, ovomucin, and ovomucoid. The ovalbumen is the chief constituent and makes up the greater part of the egg white. The conalbumen has much the same chemical properties as ovalbumen. Ovomucin and ovomucoid are glycoproteids, and are present in small amounts.

Egg yolk contains a number of different bodies, including about 15 per cent vitellin (a proteid); 20 per cent palmatin, stearin, and olein (the fatty constituents), and 0.5 per cent coloring matter, besides some lecithin (a fat-like body containing phosphorus), nuclein, etc. The yellow coloring matter in egg yolk has been separated and studied somewhat, and tho its exact character is not yet known, it is related to the yellow coloring matter of animal origin called lutein. The total phosphorus in the yolk is equivalent to a little over 1 per cent of phosphoric acid. Besides phosphorus, the yolk contains such chemical elements as calcium, magnesium, potassium, and iron in the form of salts and other chemical compounds. The protein of egg yolk was studied extensively at the Connecticut State Experiment Station. According to these investigations it contains a large amount of proteid matter combined with lecithin. The name lecithin-nucleo-vitellin is proposed for this compound, which behaves like a globulin. It is soluble in a solution of salt. As prepared in the laboratory, the lecithin-nucleo-vitellin contained from 15 to 30 per cent lecithin. A lecithin-free body insoluble in salt solution was also isolated. This was called nucleo-vitellin.

The lecithin present in egg yolk and other food materials has come to be regarded as one of the very important food constituents, as, in addition to other elements, it furnishes the body with phosporus in a form in which it may be readily assimilated. Eggs have always been recognized as a valuable food in invalid dietetics. The investigations which have been made with lecithin furnish additional proof of the truth of this belief, and egg yolks in abundance are often prescribed where it is desirable to supply a very nutritious and easily assimilated diet.

One of the constituents of egg albumen is sulfur, and the egg albumen is readily decomposed with the liberation of hydrogen sulphid. The bad odor of rotten eggs is due largely to the presence of this gas and phosphureted hydrogen, which is also formed. The shell of the egg is porous, and the micro-organisms which cause the egg to ferment—i. e., to rot, or spoil—gain access to the egg thru the minute openings. Like the mold spores, these micro-organisms are widely distributed.

**Composition of shell.**—In the table no figures are given for the composition of the eggshell, which, of course, has no food value. The shell of the hen's egg is made up very largely of mineral matter, containing 93.7 per cent calcium carbonate, 1.3 per cent magnesium carbonate, 0.8 per cent calcium phosphate, and 4.2 per cent of organic matter. The shells of goose eggs, on an average, have the following percentage composition: Calcium carbonate, 95.3; magnesium carbonate, 0.7; calcium phosphate, 0.5, and organic matter, 3.5. The shells of ducks' eggs contain 94.4 per cent calcium carbonate, 0.5 per cent magnesium carbonate, 0.8 per cent calcium phosphate, and 4.3 per cent organic matter. The shells of other eggs are doubtless of much the same composition.

## FLAVOR OF EGGS.

It is generally conceded that eggs which are perfectly fresh have the finest flavor. After eggs have been kept for a time the flavor deteriorates, even if there is no indication of spoiling. Such differences are especially important when eggs are used for table purposes. Stale eggs are not regarded as palatable, and the flavor of spoiled eggs is such that for this, if for no other reason, they are totally unfit for food. The flavor of even perfectly fresh eggs is not always satisfactory, since it is influenced more or less by the character of the food eaten by the laying hens. The New York State Experiment Station studied the effect of different rations upon the flavor of eggs. Those laid by hens fed a highly nitrogenous ration were inferior to those from hens fed a carbonaceous ration. They had a disagreeable flavor and odor, the eggs and yolk were smaller, and the keeping qualities were inferior. In a test at the Massachusetts (Hatch) Experiment Station to compare cabbage and clover rowen as the green portion of a ration for laying hens, it was found that the eggs produced on the former ration, altho heavier and possessing a higher percentage of dry matter, protein, and fat, were inferior in flavor and cooking qualities to eggs produced on the ration containing clover. The North Carolina Experiment Station studied the effect of highly flavored food upon the eggs produced. A small quantity of chopped wild-onion tops and bulbs was added to the feed of a number of hens. After about two weeks the onion flavor was noticed in the eggs laid. When the amount of onion feed was increased the flavor became so pronounced that the eggs could not be used. A week after the feeding of onions was discontinued the disagreeable flavor was no longer noticed. From these tests it appears that the flavor of eggs may be materially influenced by the food consumed. This is a matter of importance, especially when poultry are kept to supply eggs for table use.

## COLOR OF EGGSHELLS.

Considering both wild and domestic birds of all sorts, the eggshell ranges from white to deep colors thru a variety of tints and mottlings. The eggs of domestic fowls are not highly colored. Those of hens vary from white to a light or deep brownish tint, the eggs from a particular breed being very similar as regards their color. The eggs of ducks are bluish white, those of geese are commonly white. The eggs of guinea fowls are white or light brown more or less mottled with a deeper shade, and the eggs of turkeys are usually speckled with a yellowish brown.

Any special coloring of eggs of wild birds is commonly explained as a protective measure which has been developed to render the eggs inconspicuous in their normal surroundings, and therefore less easily found by their enemies. Such reasonings would indicate that the observed differences in the color of hens' eggs are due to characteristics which different breeds have inherited from remote wild ancestors. Of common breeds, Plymouth Rocks, Wyandottes, Cochins, Brahmas, and Langshans, among others, lay brown-shelled eggs, and Leghorns and Minorcas white-shelled eggs.

In studies undertaken at the Maine Experiment Station with Wyandottes and Plymouth Rocks for the purpose of establishing strains with highly developed laying qualities the recorded data show that altho both breeds lay tinted eggs the depth of color varies decidedly with individual birds in the case of each breed. By careful selection of breeding stock, therefore, it should be possible to control the color of the eggshell to a great extent so that it may be made to meet any market demand. The color of the shells, whatever its reason, is a feature which has some effect on the market value of eggs of domestic poultry, altho not upon their food value (see pp. 15 and 30), the brown-shelled eggs bringing the higher price, for instance, in the Boston market and white-shelled eggs in the New York market. In England the preference is decidedly in favor of the tinted eggs.

There is no constant relation between the color of the shell and the composition of the egg, notwithstanding the popular belief that the dark-shelled eggs are "richer." Extended investigations, in which many analyses were made of eggs from different kinds of hens, carried on at the California and Michigan experiment stations, showed plainly that there are no uniform variations in the physical properties and chemical composition of brown-shelled and white-shelled eggs. The brown-shelled eggs analyzed at the California Experiment Station were laid by Partridge Cochins, Dark Brahmas, Black Langshans, Wyandottes, and Barred Plymouth Rocks, and the white-shelled eggs by Brown Leghorns, Buff Leghorns, White Minorcas, and Black Minorcas. On an average the different colored eggs were practically alike as regards composition and total nutritive value. The analyses made in connection with the Michigan Experiment Station investigations gave results which were entirely in accord with those obtained in California.

These tests and others like them justify the statement that the eggs of any given breed of hens, whatever the color of the shells, are as nutritious as those of another breed provided the eggs are of the same size and freshness and the fowls are equally well fed.

## COLOR OF EGG CONTENTS.

Raw egg white has a more or less greenish tinge, tho apparently no specific coloring matter has been isolated from it. When the albumen is coagulated by heat in cooking the color varies from white to pale greenish or yellowish tones, hard to define, yet distinct.

The egg yolk owes its characteristic yellow color to a pigment closely akin to the yellow coloring matter of animal origin called lutein. Tho frequently the yolk is pale, the color which we associate with the egg yolk is a decided yellow. The pale-yolked eggs are often said by housekeepers to be inferior, as a given number of such yolks impart to cake or custard less of the yellow color which is looked upon as an indication of richness than do eggs of a darker yolk.

The yellow color apparently depends, in large measure at least, upon the presence of green feed in the ration, and pale-colored yolks indicate that such feed is deficient. At any rate, at the New York State Experiment Station, it was noted that hens fed only certain grains and animal feeds generally laid eggs with pale yolks, and that adding to the ration a liberal amount of fresh or dried young clover, alfalfa, or grass will, as a rule, insure the deeper yellow color, which is desired. It is reasonable to assume that it is the coloring bodies or other materials containing iron present in green feed which affect the yellow color of the egg yolk. The New York experiments indicate that the poultry raiser who desires eggs with deeper colored yolks can obtain them by feeding an abundance of such green feeds as those indicated.

That the color of the white varies more or less with different rations was also noted at the New York State Experiment Station, tho the variation was less constant than with the yolks. There is a belief that the cooked whites of eggs having shells of light tint will match in color and that the albumen of white-shelled eggs is decidedly whiter when cooked than that of eggs with tinted shells. Perhaps few persons carry preferences so far as to refuse an egg because of the color of the white, yet it is stated on good authority that in high-class hotels and restaurants, where great attention is paid to details, it has been found that the boiled eggs served must match in color. If when taken from the shell one is greenish white and the other clear white the eggs are often rejected on the ground that one of them is not of the required standard of excellence.

Altho analyses show, as has been stated above, that variations in color are not accompanied by corresponding variations in composition, it is not at all unlikely that there are differences in the flavor corresponding to the color of the egg contents and that the deep yellow yolks have a more pronounced flavor than the pale yolks. At any rate, as long as preferences for deep-colored yolks and clear whites exist the poultry raiser who caters to a fancy market should take them into account.

It is a matter of common observation that when eggs are boiled the yolk where it joins the white has often a more or less greenish color. Contact with the white renders the surface of the yolk somewhat alkaline. Experiment has shown that when egg white and many other proteids are heated hydrogen sulphid or some other volatile sulfur body is quite commonly liberated in small amounts, and Rubner has found that the discoloration of the egg yolk is due to the action, in the presence of alkali, of hydrogen sulphid thus produced on the iron of the vitellin of egg yolk.

Silver is very quickly turned dark by air containing sulfur fumes. The blackening of silver forks and spoons, so commonly noted when they come in contact with eggs at table, is due to the action upon the silver of the small amount of hydrogen sulphid or other sulfur body liberated from the egg white when it is cooked.

## DIGESTIBILITY OF EGGS.

Raw eggs or eggs only slightly cooked are commonly said to be very digestible, the idea being obviously that they digest readily without giving rise to pain or other physical discomfort. The term digestibility has another meaning, and one which is commonly intended when it is used in the discussion of food values. This refers to the thoroness of digestion—that is, to the total amount of material which any food gives up to the body in its passage thru the digestive tract. Since only soluble or possibly emulsified matter can pass thru the walls of the stomach and intestines and be taken up into the circulation to nourish the body, it follows that only material which is soluble or is rendered soluble by the action of pepsin, trypsin, and other ferments in the digestive juices, is truly digestible. The original condition of food, the method of cooking, and the amount eaten at a given time, are among the factors which determine the quantity of any given material which can be digested.

Statements are frequently made with regard to the length of time required to digest different foods. Many of these are doubtless far from accurate, as the subject is not easy to study. By methods of artificial digestion the length of time required to render different foods soluble has been frequently tested. It is possible to use in the experiments the same digestive ferments which occur in the body and to approximate body temperature, etc., but it is quite certain that all the conditions of digestibility in the body can not be reproduced in the laboratory. The results obtained are interesting and often valuable, but it is worthy of note that careful investigators are much slower to make sweeping deductions from them than are popular writers on the subject.

More than fifty years ago Doctor Beaumont, a United States Army surgeon, had an excellent opportunity for studying digestibility in the stomach. A healthy young man was accidentally wounded in the stomach by the discharge of a musket. In time the large wound healed, leaving a permanent opening into the stomach. This was ordinarily closed by a valvular flap made by a fold of the stomach lining, which could be easily pushed aside and the interior of the stomach examined or the stomach contents removed as desired. Strange as it may seem, this could be done without giving the subject pain or annoyance, nor was his general health abnormal after the wound had healed in this curious way. For many years after the time of the accident (1822) the man was under Doctor Beaumont's care and observation. Very many experiments were made on the length of time required by different foods for digestion in the stomach, or " chymification." Many artificial digestion experiments were also made, using gastric juice removed from the man's stomach. Altho these investigations were carried on long before the theories and methods of physiological chemistry now accepted were known, so much care was taken in making the experiments and in recording the experimental data that the work has never ceased to be of great value as well as interest. However, it should not be forgotten that Doctor Beaumont studied only digestion in the stomach; his work throws no light on digestion in the intestines. This is of especial importance in the case of starchy foods, as the digestion of starch, which is begun by the saliva, ce the stomach but is resumed in the intestines. The expe reported include among others tests of the length of time re to digest eggs, hard and soft boiled, fried, roasted, and raw, raw eggs were sometimes whipt and sometimes not. In a tests fresh eggs were used. Hard-boiled and fried eggs ea quired $3\frac{1}{2}$ hours for digestion in the stomach, i. e., for the form of chyme; soft-boiled eggs required 3 hours; roasted eggs, $2\frac{1}{4}$ h raw eggs, not whipt, 2 hours, and raw eggs, whipt, $1\frac{1}{2}$ hours. tested by the methods of artificial digestion followed by Doctor mont, which approximated bodily conditions as closely as h able to make them, the hard-boiled eggs required 8 hours for tion; soft-boiled eggs, $6\frac{1}{2}$ hours; raw eggs, not whipt, $4\frac{1}{4}$ and raw eggs, whipt, 4 hours. The two methods gave results agree in the relative length of time required for the digesti of the different samples, tho not in the actual time required. Si results were obtained by the two methods with the greater p the large number of foods studied. One of Doctor Beau general deductions was that most of the common foods require 2 to 4 hours to digest in the stomach. He says further:

> The time required for the digestion of food is various, depending quantity and quality of the food, state of the stomach, etc., but ordinarily required for the disposal of a moderate meal of the fibr of meat, with bread, etc., is from 3 to $3\frac{1}{2}$ hours.

As regards the time required for digestion in the stomac be seen that in this investigation eggs compare favorably w common foods. It must be remembered that digestion co the intestine, and that no data are furnished by these ex for judging of this factor. This is an important matter material which escapes digestion in the stomach may b digested later in the intestine. This fact seems to have b overlookt in the discussion of Doctor Beaumont's work.

Some German investigations which have to do with the time different foods remain in the stomach have also show eggs eaten raw, poached, or in the form of an omelet, stomach in 2 to 3 hours, being included in the same clas oysters, white bread, etc. The ordinary kinds of fresh m the stomach in 3 to 4 hours, and some smoked meats an in 4 to 5 hours. Another investigator, who has divide foods into four classes according to the ease with which digested, includes raw or soft-cooked eggs in the most class, along with beef tea, milk, etc. Few investigations reported regarding the comparative digestibility of the parts of the egg. On the basis of a number of experime ncludes that raw or half-raw egg yolk is very readily digested. He und that two to four raw yolks leave the stomach in 70 to 100 inutes, and that one or two yolks taken in a cup of hot coffee with me sugar and milk leave the stomach in 60 to 70 minutes.

Among later experiments on the digestibility of eggs by artificial ethods, the work of the Minnesota Experiment Station may be ted. The object was to study the thoroness as well as the ease of gestion. Five experiments were made by means of a pepsin solu- on with eggs cooked under different conditions. Eggs were cooked r 3 minutes in water at 212° F., giving a "soft-boiled" egg, and r 5 minutes and 20 minutes at the same temperature. The egg iled 3 minutes and digested for 5 hours in pepsin solution, com- red with one boiled 20 minutes and treated in the same way, owed 8.3 per cent undigested protein in the former, against 4.1 er cent undigested protein in the latter. Under similar treatment e egg boiled 5 minutes gave 3.9 per cent undigested protein. In l cases the egg was quite thoroly digested. Another trial was then ade in which the eggs were cooked for periods of 5 and 10 minutes n water at 180° F.—that is, the albumen was coagulated at a lower emperature than that of boiling water. In both of these cases the protein was entirely digested in 5 hours. These results would indi- ate that while the time and the temperature of cooking have some effect upon the rate of digestion, they do not very materially affect the total digestibility.

As regards the general deduction that eggs cooked for different lengths of time vary somewhat in the length of time for digestion, under the experimental conditions the results agree quite closely with those obtained by Doctor Beaumont.

Experiments have also been made with man to learn how thoroly eggs are digested. In such tests it is usual to analyze the food and the feces, the latter being assumed to consist principally of undigested food. Deducting the amount of the different nutrients in the feces from the total amount consumed, shows how much of each nutrient was digested. Such an experiment was made at the Minnesota Experiment Station with a healthy man. A very considerable portion of the nitrogenous material and fat of the ration was furnished by eggs, the other foods eaten being potatoes, milk, and cream. About 90 per cent of the total nitrogenous material and over 90 per cent of the fat consumed were digested. In experiments at the University of Tennessee, with healthy men on a diet of bread, milk, and eggs, from 93 to 95 per cent of both the protein and fat were digested. The conclusion, therefore, seems warranted that, as shown by composition and digestibility, eggs possess the high nutritive properties which are popularly assigned to them.

A German investigator, Rubner, some years ago tested the digestibility of hard-boiled eggs with a healthy man. No other food was eaten with the eggs. It was found that 95 per cent of the total dry matter and 97 per cent of the protein were digested. The fat was also very thoroly assimilated. The percentage of total dry matter and protein digested was about the same as was found in similar experiments in which meat only was eaten, while the percentage of fat digested was larger. Discussing these tests, Rubner says in effect:

> From the fact that eggs are as completely digested as meat, it does not follow that they are digested in the same time, or that hard-boiled eggs do not produce more disturbance in the digestive organs. It is highly probable that there is no difference in the thoroness of digestion of hard-boiled and soft-boiled eggs.

Jorissenne, discussing the digestibility of eggs with reference to some recent European work on the subject, states that he regards the yolk of raw, soft-boiled, and hard-boiled eggs as equally digestible. The white of soft-boiled eggs, being semiliquid, offers little more resistance to the digestive juices than raw white. The white of a hard-boiled egg is not generally very thoroly masticated. Unless finely divided, it offers more resistance to the digestive juices than the fluid or semifluid white, and undigested particles may remain in the digestive tract many days and decompose. From this deduction it is obvious that thoro mastication is a matter of importance. Provided mastication is thoro, marked differences in the completeness of digestion of the three sorts of eggs, in the opinion of the writer cited, will not be found.

Perhaps the most extended study of the digestibility of eggs on record was carried on at St. Petersburg by Tikhvinski. Two experiments, each divided into two periods of seven days, were made with a healthy man. In the first period of the first experiment the diet consisted of hard-boiled eggs, bread, and meat; in the second, of soft-boiled eggs with bread and meat. The second experiment was made under similar conditions, except that the soft-boiled eggs were used in the first period and the hard-boiled in the second. The eggs furnished about one-fifth of the total protein and two-thirds of the total fat of the diet. Considering the average results of the whole investigation or those of each experiment, the rations containing the eggs cooked in the two ways proved equally digestible, 90 to 91 per cent of the protein and 95 per cent of the fat consumed being retained in the body. As the only factor in the experiments which varied was the time of cooking the eggs, the deduction seems warranted that the hard and soft boiled were equally digestible.

Lebbin reports a digestion experiment with a healthy man in which 22 eggs were consumed in ten days. In round numbers the following coefficients of digestibility were obtained: Dry matter 95, protein 98, total ether extract 96, lecithin 91, neutral fat 98, and ash 70 per cent. Stern, whose work was referred to above, concluded that egg yolks were very thoroly assimilated, as he found only 1.5 to 3.5 per cent of the fat of the egg yolk in the feces, a smaller proportion than was found in the case of milk fat and other animal fats. He states, further, that egg yolks stimulate gastric digestion and in addition contain a ferment which has some action upon starch.

Schilling made extended microscopical studies of the undigested material in feces from a variety of foods. He found that raw egg and egg slightly cooked, as in hot soup, was thoroly digested. In the case of hard-boiled eggs bits of shell or skin of the egg accidentally eaten were recovered in the feces. The egg itself was apparently quite thoroly digested. When fried egg or omelet was eaten some small bits of brown, hard-cooked egg were recovered, but in general the tests showed that the eggs were very thoroly assimilated.

In connection with the nutrition investigations of this Department, the average coefficients of digestibility have been deduced for different kinds of food materials, that for the protein of eggs being 97 per cent and for the fat 95 per cent.

From all the evidence it seems fair to conclude that eggs are quite thoroly digested and that the length of time of cooking has less effect upon this factor than upon the time required for digestion. In a healthy man the latter consideration is probably not a matter of much importance. In the diet of sick persons and invalids it may be more important. Diet in such cases, however, is a matter for the attention of skilled physicians.

In some of the experiments referred to above the eggs were used alone; in others, as a part of a more or less simple mixt diet. The effect of one food upon the digestibility of another is a matter concerning which little is definitely known. It is possible that when two foods are eaten together the digestibility of either or both is (1) unchanged, (2) increased, or (3) diminished.

Apparently no experiments have been made in which the problem was studied with special reference to eggs combined with other foods. However, artificial digestion experiments were made by Fraser on the effect of beverages on the digestibility of a number of foods including raw and cooked egg albumen, which led to the deduction that tea, coffee, and cocoa retarded somewhat the digestibility of the nitrogenous constituents of eggs, altho the effect was less marked with coffee than with the other beverages. Water did not have this effect. Tho interesting in themselves, too wide application should not be made of the results of such tests, for even if the beverages retarded digestibility somewhat, it does not necessarily follow that this effect was harmful or that the thoroness of digestion was altered.

## THE PLACE OF EGGS IN THE DIET.

Eggs are used in nearly every household in some form or another in varying amounts. From the results of the numerous dietary studies made under the auspices of this Department and by the agricultural experiment stations, it has been calculated that on an average eggs furnish 3 per cent of the total food, 5.9 per cent of the total protein, and 4.3 per cent of the total fat used per man per day. Cheese was found to furnish 0.4 per cent of the total food, 1.6 per cent of the total protein, and 1.6 per cent of the total fat, while the milk and cream together furnish 19.9 per cent of the total food, 10.5 per cent of the total protein, and 10.7 per cent of the total fat. Milk and cream together also furnish some cabohydrates, while eggs and cheese furnish no appreciable amount of this group of nutrients. Considering some of the common meats, beef and veal together were found to furnish 10.3 per cent of the total food, 24.6 per cent of the total protein, and 19.5 per cent of the total fat. The corresponding values for mutton and lamb together were 1.4, 3.3, and 3.8 per cent.

It will be seen that, judged by available statistics, eggs compared favorably with the more common animal foods as regards both the total food material and the total protein and fat furnished by them in the average daily dietary. In other words, investigations show that the high food value of eggs is appreciated and that they constitute one of the very important articles of diet in the American household.

The amount of nutritive material which a given amount of eggs will furnish at any stated price per dozen may be readily calculated. When eggs are 15 cents per dozen, 10 cents expended for this food will furnish 1 pound total food material, containing 0.13 pound protein and 0.09 pound fat, the whole having a fuel value of 635 calories. At 25 cents per dozen, 10 cents' worth of eggs will furnish 0.60 pound total food material, supplying 0.08 pound of protein, 0.05 pound of fat, and 380 calories. At 35 cents per dozen, 10 cents will procure 0.43 pound total food material, containing 0.06 pound of protein, 0.04 pound of fat, and furnish 275 calories. Ten cents expended for beef at 8 cents per pound will furnish 1.25 pounds total food material, containing 0.24 pound protein, 0.16 pound fat, and 1,120 calories. Expended for beef sirloin at 20 cents per pound it will furnish 0.5 pound total food matter, containing 0.08 pound protein, 0.09 pound fat, and 520 calories. If wheat bread is purchased at 5 cents per pound, 10 cents will pay for 2 pounds of total food material containing 0.18 pound protein, 0.03 pound of fat, 1.06 pounds carbohydrates, and 2,430 calories.

In many of the dietary studies made in the United States data were recorded of the cost of different foods and the relative amount of nutritive material contributed by each in proportion to the total cost. Compared with other foods at the usual prices, eggs at 12 cents per dozen were found to be a cheap source of nutrients; at 16 cents per dozen they were fairly expensive, and at 25 cents per dozen and over they were very expensive. This point needs some further discussion, since the value of eggs can not fairly be estimated solely on the basis of the amount of nutrients furnished. Eggs are also valuable for giving variety to the diet and for furnishing a light, easily digested, nitrogenous food, especially suitable for breakfast or other light meal, an important item for those of sedentary habits.

Many families of moderate means make a practise of buying fresh meat for but one meal a day—i. e., dinner—using for breakfast either bacon, dried beef, codfish, or left-over meats, etc., and for lunch or supper, bread and butter and the cold meat and other foods remaining from the other two meals, with perhaps the addition of cake and fresh or preserved fruit. It is the thrifty housekeeper, who uses all her material as economically as possible in some such way, who is likely to fall into the error of excluding eggs at higher prices almost entirely from her food supply. If her economy was directed principally to restricting the use of eggs in the making of rich dessert dishes, cake, and pastry, one might not only refrain from criticizing but welcome the circumstances which necessitated the making of simple and therefore more wholesome desserts. But usually the housekeeper economizes by the more obvious method of omitting to serve them as a meat substitute.

The statement so frequently made by housekeepers that eggs at 25 cents per dozen are cheaper than meat is true in one sense. Not, of course, with reference to the total amount of nutrients obtained for the money expended, but because a smaller amount of money is needed to furnish the meal. That is to say, whereas at least 1.25 pounds of beefsteak, costing 25 cents, at 20 cents per pound, would be necessary to serve five adults, in many families five eggs, costing 10 cents, at 25 cents per dozen, would serve the same number and probably satisfy them equally well. If the appetites of the family are such as to demand two eggs per person, doubling the cost, it is still 20 per cent less than the steak. Many persons eat more than two eggs at a meal, but the average number per person it is believed does not generally exceed two in most families. A hotel chef is authority for the statement that at least one-half the orders he receives are for one egg. Frequently when omelets, soufflés, creamed eggs, and other similar dishes are served in place of meat or fried, poached, or boiled eggs, less than one egg per person is used.

These statements must not be understood as advocating
of eggs at any price, but merely as pointing out tha

higher prices the occasional use of eggs in place of meat need not be regarded as a luxury. This is illustrated by observations made by Miss Bevier and Miss Sprague[a] at Lake Erie College, Ohio, during a dietary study of some 115 women, most of them students. It was found that the amount and cost of certain foods required for a single meal, when any one of them was served, was as follows:

*Comparative amount and cost of certain foods required, per meal, by women students' club.*

| | Amount required. | Price per pound. | Total cost per meal. |
|---|---|---|---|
| | *Pounds.* | *Cents.* | |
| Beefsteak | 36 | 17 | $6.12 |
| Mutton chops | 45 | 14 | 6.30 |
| Hamburg steak | 24 | 12½ | 3.00 |
| Sausage | 30 | 12 | 3.60 |
| Bacon | 12 | 9 | 1.08 |
| Dried beef | 4 | 23 | [b] .92 |
| Eggs | [c] 15 | [d] 14⅔ | 2.20 |
| Do | [c] 15 | [e] 16⅔ | 2.50 |

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[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 91, and unpublished data furnished by Miss Sprague.

[b] Milk, butter, and flour required for the dried beef, when creamed, would increase the cost somewhat.

[c] 15 pounds = 10 dozen eggs.

[d] Or 22 cents per dozen.

[e] Or 25 cents per dozen.

At the price at which board was furnished steaks and chops were too expensive for use as breakfast dishes. Bacon or dried beef was considered cheap. Hamburg steak and sausage were regarded as practicable and were occasionally used. When the investigation was undertaken, the opinion was commonly held that eggs at 22 cents per dozen were expensive, and at 25 cents per dozen so dear that they could not be used, yet it will be seen by reference to the above table that at both prices the amount of eggs actually required to satisfy the members of the club cost less than any of the foods except bacon and dried beef. Observation showed that many of the students did not care for Hamburg steak or sausage and would eat eggs. If any boiled eggs were left they could be used for garnishing salads or in other ways, and therefore need not be wasted, while it was difficult to utilize the remnants of Hamburg steak or sausage in such a way that they were relished. It appears, therefore, that as regards both economy and palatability, the use of eggs in this case as a breakfast dish was warranted.

In the instance cited it is known that 10 dozen eggs, 30 pounds of sausage, 24 pounds of Hamburg steak, 12 pounds of bacon, and the amounts of the other foods mentioned in the table were not equivalent as regards the quantity of nutrients furnished, altho any of the foods could be used as a breakfast dish in the quantity mentioned and give satisfaction to the club. It must be remembered, however, at other foods were served with the meat or eggs, and that the total ount of nutrients consumed at the meal may not have varied eatly from day to day, altho the menu was quite different. Further-ore, physiologists believe that the quantities eaten each day need t conform exactly to the accepted dietary standard, but rather that e daily average thruout a considerable period must not vary very eatly from it. A deficiency on one day may be easily made good an abundance the next. When, as was the case at Lake Erie Col-ge, each meal is abundant, the average daily diet corresponds with asonable closeness to the commonly accepted dietary standard, and e persons consuming it have every appearance of being properly urished, such substitutions of foods of unlike nutritive value seem stifiable on theoretical as well as on practical grounds. It hardly eeds to be said that the instance cited is in accord with the ordinary ousehold practise.

It is generally recognized that eggs require less time for cooking an most common foods, and this may be seen from experiments arried on by the Association of Collegiate Alumni of Boston in a udy of the relative cost of foods cooked with different kinds of fuel nd related questions. There are undoubtedly cases in which a small aving of gas or other fuel in the preparation of a dish is of impor-ance, but the saving of fuel would perhaps be most often less impor-ant than a saving of time. Without question a reason for the popu-arity of eggs in most households is that they may be so easily and quickly prepared for the table in appetizing ways.

Eggs and the foods into which they enter are favorite articles of diet with very many, if not most families, and in this as in other cases the income and the need for economy must determine how far and in what way they are to be used when they are high in price. Judged by their composition and digestibility, eggs are worthy of the high opinion in which they are usually held. Furthermore, they are gen-erally relished. Altho the physiological reasons were perhaps diffi-cult to find, it was long ago conceded that the attractiveness and pala-tability of any food must not be forgotten in considering its true nutritive value. Refinement in matters of diet should keep pace with growth in general culture, and foods which please the esthetic sense as well as satisfy the hunger are certainly to be preferred to those which serve the latter purpose only, if they can be provided with the income at one's command.

## MARKETING AND PRESERVING EGGS.

In earlier times eggs, if sold at all, were marketed near the place where they were produced. Many are still sold in local markets; but with improved methods of transportation the market has been extended and large quantities of eggs are shipped from this c and Canada not only to distant points in America, but to E and more distant countries. For shipping long distances th special egg cases, and the shipper should select the kind w preferred in the market which he desires to reach. The way in eggs are graded commercially naturally varies more or less in ent markets, but in general the grading depends upon fre flavor, uniformity, size, appearance, color, and similar facto is important that, as is the case with perfectly fresh eggs o quality, the egg contents should almost completely fill the she that the egg white should be jelly-like rather than watery i sistency. It is said that these qualities are affected by the cha of the rations fed, and that in the case of fowls given a well-ba ration the shells will be well filled and the eggs of good cons The color of the yolk is undoubtedly a factor which influences in their judgment of the quality of eggs. This is undoubted fluenced by food, and it is claimed that yellow corn, especiall an abundance of green feed, tends to produce eggs with dee yellow yolks.

Only perfectly fresh eggs should be marketed. The shells always be wiped clean, if necessary, and the eggs graded as r size. In some markets brown eggs are preferred to white, noted elsewhere. It is stated that in the Boston market shelled eggs, such as are laid by Partridge Cochins, Dark Br Barred Plymouth Rocks, etc., sell at from 2 to 5 cents per more than white-shelled eggs, such as are laid by Brown Le Buff Leghorns, and White and Black Minorcas. In the Ne market, on the other hand, white-shelled eggs bring the highe That the color of the shell has no relation to the food value, a by analysis, is pointed out on another page (p. 15). It h found that in order to supply the demand which exists markets for brown-shelled eggs the shells are sometimes ar colored.

Eggs which are to be shipped, whether with or without attempt at preservation, should be perfectly fresh, and sho be packed in any material which has a disagreeable odo straw or bran will injure the flavor and keeping qualitie packed in it. When shipped, eggs should not be placed thing which has a disagreeable or strong odor. Keeping e cargo of apples during transportation has been known to i flavor and also their market value. As previously not organisms may enter the egg thru the minute pores in the set up fermentation which ruins the egg. In other words, rotten. The normal eggshell has a natural surface coatin laginous matter, which hinders the entrance of these harmful organisms for a considerable time. If this coating is removed or softened by washing or otherwise, the keeping quality of the egg is much diminished. If the process of hatching has begun, the flavor of the egg is also injured.

There are many ways of testing the freshness of eggs which are more or less satisfactory. "Candling," as it is called, is one of the methods most commonly followed. The eggs are held up in a suitable device against a light. The fresh egg appears unclouded and almost translucent; if incubation has begun, a dark spot is visible, which increases in size according to the length of time incubation has continued. A rotten egg appears dark colored. Egg dealers become very expert in judging eggs by testing them by this and other methods.

The age of eggs may be approximately judged by taking advantage of the fact that as they grow old their density decreases thru evaporation of moisture. According to Siebel a new-laid egg placed in a vessel of brine made in the proportion of 2 ounces of salt to 1 pint of water, will at once sink to the bottom. An egg 1 day old will sink below the surface, but not to the bottom, while one 3 days old will swim just immersed in the liquid. If more than 3 days old, the egg will float on the surface, the amount of shell exposed increasing with age; and if 2 weeks old, only a little of the shell will dip in the liquid.

The New York State Experiment Station studied the changes in the specific gravity of the eggs on keeping and found that on an average fresh eggs had a specific gravity of 1.090; after they were 10 days old, of 1.072; after 20 days, of 1.053, and after 30 days, of 1.035. The test was not continued further. The changes in specific gravity correspond to the changes in water content. When eggs are kept they continually lose water by evaporation thru the pores in the shell. After 10 days the average loss was found to be 1.60 per cent of the total water present in the egg when perfectly fresh; after 20 days, 3.16 per cent, and after 30 days, 5 per cent. The average temperature of the room where the eggs were kept was 63.8° F. The evaporation was found to increase somewhat with increased temperature. None of the eggs used in the 30-day test spoiled.

Fresh eggs are preserved in a number of ways which may, for convenience, be grouped under two general classes: (1) Use of low temperature, i. e., cold storage; and (2) excluding the air by coating, covering, or immersing the eggs, some material or solution being used which may or may not be a germicide. The two methods are often combined. The first method owes its value to the fact that micro-organisms, like larger forms of plant life, will not grow below a certain temperature, the necessary degree of cold varying with the species. So far as experiment shows, it is impossible to kill these minute plants, popularly called "bacteria" or "germs," by any degree of cold; and so, very low temperature is unnecessary for preserving eggs, even if it were not undesirable for other reasons, such as injury by freezing and increased cost. According to a recent report of the Canadian commission of agriculture and dairying:

> When fresh-laid eggs are put into cold storage with a sweet pure atmosphere at a temperature of 34° F., very little, if any, change takes place in their quality. The egg cases should be fairly close to prevent circulation of air thru them, which would cause evaporation of the egg contents.
>
> Eggs should be carried on the cars and on the steamships [at a temperature of] from 42° to 38°. When cases containing eggs are removed from the cold-storage chamber, they should not be opened at once in an atmosphere where the temperature is warm. They should be left for two days unopened, so that the eggs may become gradually warmed to the temperature of the air in the room where they have been deposited, otherwise a condensation of moisture from the atmosphere will appear on the shell and give them the appearance of sweating. This so-called "sweating" is not an exudation thru the shell of the egg, and can be entirely prevented in the manner indicated.

It is stated by Siebel that in practise in this country 32° to 33° F. is regarded as the best temperature for storing eggs, altho some American packers prefer 31° to 34°, while English writers recommend a temperature of 40° to 45° as being equally satisfactory. The amount of moisture in the air in the cold-storage chamber has without doubt an important bearing on this point. Eggs are generally placed in cold storage in April and the early part of May. If placed in storage later than this time, they do not keep well. They are seldom kept in storage longer than a year. Eggs which have been stored at a temperature of 30° must be used soon after removal from storage, while those stored at 35° to 40° will keep for a considerable time after removal from storage, and are said to have the flavor of fresh eggs. The author cited states that eggs for market, especially those designed for cold storage, should not be washt. Stored eggs should be turned at least twice a week, to prevent the yolk from adhering to the shell.

Eggs are sometimes removed from the shells and stored in bulk, usually on a commercial scale, in cans containing about 50 pounds each. The temperature recommended is about 30° F., or a little below freezing, and it is said they will keep any desired length of time. They must be used soon after they have been removed from storage and have been thawed.

The substances suggested and the methods tried for excluding air conveying micro-organisms to the egg, and for hindering the growth of those already present, are very numerous. An old domestic method is to pack the eggs in oats, bran, or salt. Another, which has ays had many advocates, consists in covering the eggs with lime-er which may or may not contain salt. The results obtained by methods are not by any means uniform. Sometimes the eggs ain fresh and of good flavor, and at other times they spoil. ently, in Germany, twenty methods of preserving eggs were tested. eggs were kept for eight months with the following results: Those erved in salt water, i. e., brine, were all bad, not rotten, but alatable, the salt having penetrated the eggs. Of the eggs erved by wrapping in paper, 80 per cent were bad; the same pro-ion of those preserved in a solution of salicylic acid and glycerin e unfit for use. Seventy per cent of the eggs rubbed with salt e bad, and the same proportion to those preserved by packing ran, or covered with paraffin or varnished with a solution of erin and salicylic acid. Of the eggs sterilized by placing in ing water for 12 to 15 seconds, 50 per cent were bad. One-half hose treated with a solution of alum or put in a solution of ylic acid were also bad. Forty per cent of the eggs varnished water glass, collodion, or shellac were spoiled. Twenty per of the eggs packed in peat dust were unfit for use, the same per-age of those preserved in wood ashes, or treated with a solution oric acid and water glass, or with a solution of permanganate of sh were also bad. Some of the eggs were varnished with line; these were all good, as were those preserved in limewater n a solution of water glass. Of the last three methods, preser-on in a solution of water glass is especially recommended, since ishing the eggs with vaseline is time consuming, and treatment limewater sometimes communicates to the eggs a disagreeable r and taste.

any of these methods have been tested at the agricultural experi-t stations in this and other countries. The Canada Station found infertile eggs kept much better than fertile eggs when packed in . In view of the fact that preservation in brine has been said to re the eggs by giving them an unpleasant, salty taste, experiments e recently made at Berlin University to learn the proportion of which entered the eggs when placed in brine of varying strength. was found by the investigator that with a saturated or half-rated solution, the salt entered the eggs at first very quickly, and r much more slowly. After remaining 4 days in the saturated tion, an egg contained as much salt as one which remained 4 to eeks in a 1 to 3 per cent solution. If kept in the saturated solu-4 weeks, 1.1 per cent salt was found in the yolk and 1.5 per t in the white of the eggs. None of the eggs tested was spoiled. en a 1 to 5 per cent solution was used, the eggs kept well for 4 ks and did not have a salty flavor. These instances are sufficient

to show that any given method will
hands, and this is not surprizing, si
uniformly fresh, nor is it at all
conditions are uniform.

In the last two or three years the
a solution of water glass has been
way and in laboratories. The No
has been especially interested in the
a 10 per cent solution of water gl
that "at the end of 3½ months eg
part of August still appeared to be
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glass the yolk retained its normal
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Water glass or soluble glass is
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glass offered for sale is very alkalir
used, as the eggs preserved in it
water should be used in making the

and cool it before mixing with the water glass. The solution should be carefully poured over the eggs packed in a suitable vessel, which must be clean and sweet, and if wooden kegs or barrels are used they should be thoroly scalded before packing the eggs in them. The packed eggs should be stored in a cool place. If they are placed where it is too warm, silicate deposits on the shell and the eggs do not keep well. Only clean eggs should be packed, but the North Dakota Experiment Station found it best not to wash the eggs before packing, as this removes the natural mucilaginous coating on the outside of the shell. The station states that 1 gallon of the water glass will make sufficient solution for 50 dozen eggs if they are properly packed.

If it is desired to preserve eggs in limewater, the solution may be prepared by placing 2 or 3 pounds of unslaked lime in 5 gallons of water and allowing the mixture to stand until the lime settles and the liquid is clear. The eggs should be placed in a clean earthenware jar or other suitable vessel and covered with the clear limewater. Sometimes a pound of salt is used with the lime, but it is said that such a mixture imparts a slight taste of lime to the eggs.

It is, perhaps, too much to expect that eggs packed in any way will be just as satisfactory for table use as the fresh article. The opinion seems to be, however, that those preserved with water glass are superior to most of those preserved otherwise. The shells of eggs preserved in water glass are apt to crack in boiling. It is stated that this may be prevented by puncturing the blunt end of the egg with a pin before putting it into the water.

In tests carried on at the Washington Experiment Station water glass gave better results than limewater or a patent egg preservative. It was found that the eggs packed in water glass were not only satisfactory after having been packed for a number of months, but also when kept for four weeks after removal from the preservative solution.

In a study of the relative merits of different egg preservatives carried on by the Ontario Agricultural and Experimental Union losses in weight were recorded. When eggs were packed in salt the loss due to evaporation was equal to 33 per cent of the contents. When the eggs were greased this was reduced to 25 per cent. No loss was noted when the eggs were preserved in water-glass solution or limewater.

In the East Indian Archipelago salted ducks' eggs are an article of diet. The new-laid eggs are packed for 2 or 3 weeks in a mixture of clay, brick dust, and salt. They are eaten hard boiled. It is said that in this region and in India turtle eggs are also preserved in salt. These products, while unusual, do not necessarily suggest an unpleasant article of diet. The same can hardly be said of a Chinese product, which has often been described. Ducks' eggs are buried in the ground for 10 or 12 months and undergo a peculiar fermentation. The hydrogen sulphid formed breaks the shell and escapes while the egg becomes hard in texture. It is said that the final product does not possess a disagreeable odor or taste. Eggs treated in this or some similar way are on sale in the Chinese quarter of San Francisco, and very likely in other American cities. A sample which was examined had the appearance of an egg covered with dark-colored clay or mud.

## SELLING EGGS BY WEIGHT.

Since eggs vary more or less in size it has been proposed that they should be sold by weight rather than by the dozen, which is the usual custom in this country. The North Carolina Experiment Station, in investigating this point, recorded the weight of eggs per dozen and the number produced during six months by pullets and old hens of a number of well-known breeds, and by ducks. Generally speaking, larger eggs were laid by hens than by pullets of the same breed. The eggs laid by Pekin ducks (old and young) averaged 35.6 ounces per dozen, and were heavier than those laid by any breed of hens. Of the different breeds of hens tested the largest eggs weighed 28 ounces per dozen, and were laid by Light Brahmas. The Black Langshan and Barred Plymouth Rock hens' eggs weighed a little over 26 ounces per dozen, while those laid by Single Comb Brown Leghorns, late-hatched Plymouth Rock, White Wyandotte, and Buff Cochin hens ranged from 21.7 to 23.7 ounces per dozen.

Of the pullets, the heaviest eggs (weighing 26.5 ounces per dozen) were laid by the Black Minorcas, the lightest by the Single Comb Brown Leghorns and Silver-Laced Wyandottes. These weighed 17.5 and 22.1 ounces per dozen, respectively. The Barred Plymouth Rock, White Plymouth Rock, White Wyandotte, Black Langshan, and Buff Cochin pullets' eggs all weighed not far from 24 ounces per dozen. As will be seen, the variation in the weight of the eggs was considerable. In tests carried on at the Maine Experiment Station it was noticed that eggs from hens that laid the greatest number were on an average smaller in size than those from hens producing fewer eggs. The percentage of fertility was also less in the former than in the latter.

In the North Carolina test all of the eggs, regardless of size, had a local market value of 13.5 cents per dozen at the time of the investigation. If a dozen Single Comb Brown Leghorn pullets' eggs weighing 17.5 ounces were worth 13.5 cents per dozen, or 12 cents per pound, the eggs of the other breeds would be actually worth from 16.3 cents for

Single Comb Brown Leghorn hens to 21.6 cents per dozen for the
t Brahma hens, or from 20.7 to 60 per cent in excess of their
ket value. The eggs of the Pekin ducks would be worth 26.7
s, or 97.8 per cent above their market value. On the basis of the
lts obtained, the station advocates selling eggs by the pound instead
y the dozen. It is said that the egg packers and dealers maintain
this method would increase the cost of the eggs, owing to the
a handling necessary and the consequent breakage. An apparent
ction to selling eggs by weight is that they are not generally used
ne household in this way. Most recipes call for eggs by number
not by weight. There is no question that weighing the eggs
ld be more accurate, and recipes are occasionally met with in
ch this method is followed.

## ESICCATED EGGS, EGG POWDERS, AND EGG SUBSTITUTES.

ifferent methods of evaporating or desiccating whole egg yolks
whites have been proposed and several products which claim
e thus prepared are now on the market. It is said that the egg
ried in or out of a vacuum, usually by a gentle heat or by cur-
s of air. When placed on the market the dried egg is usually
nd. Sometimes salt, sugar, or both have been used as preserva-
s. As will be seen by reference to the table of composition (p.
such material is merely egg from which the bulk of the water
been removed. If the process of manufacture is such that the
luct is palatable and keeps well, the value of evaporated eggs
er many circumstances is evident.

his material is used by bakers to some extent as being cheaper
n fresh eggs are high in price. It is also used in provisioning
ps and expeditions, since desiccated foods have the advantage
a higher nutritive value in proportion to their bulk than the
e materials when fresh. Fresh eggs contain about 25 per cent
lry matter. If all the water is removed in preparing evaporated
s, 1 pound will furnish nutritive material equivalent to about 4
nds of fresh eggs. A commercial egg product which was tested
eared to be dried egg coarsely ground. For use it was thoroly
t with a small quantity of water. The mixture could then be
d or made into an omelet, etc., and was found to be very palatable,
ely resembling in taste the same dishes made from fresh eggs.

n egg substitute has been manufactured from skim milk. It is
to contain the casein and albumen of the milk mixt with a little
r, and is put up in the form of a paste or powder. Such material
vidently rich in protein and, according to reports apparently
ble, is used in considerable quantities by bakers and confection-
in place of fresh eggs.

Egg substitutes have been devised which consist of mixtu animal or vegetable fats, albumen, starch or flour, coloring and some leavening powder in addition to the mineral matters to those found in the egg. Such products are designed to re eggs in composition.

Other egg substitutes have been marketed which contain littl albumen, but apparently consist quite largely of starch, colore or less with some yellow substance. These goods are specially mended for making custards and puddings similar in appear those in which fresh eggs are used. There is no reason to that such products can not be made so that they will be p wholesome. The fact must not be overlookt that in the diet t not replace fresh eggs, since they do not contain much nitr matter or fat. As recently pointed out in one of the medical j this may be an important matter if such an egg substitute is the diet of invalids, especially if the composition of the egg su is not known, and it is employed with the belief that, like contains an abundance of protein.

## POSSIBLE DANGER FROM EATING EGGS.

Occasionally a person is found who is habitually made ill b eggs, just as there are those who can not eat strawberries foods without distress. Such cases are due to some personal crasy, showing that in reality "one man's meat is anothe poison." A satisfactory explanation of such idiosyncrasy be lacking.

Overindulgence in eggs, as is the case with other foods, ma indigestion or other bad effects. Furthermore, under certai tions eggs may be the cause of illness by communicating terial disease or some parasite. It is possible for an egg t infected with micro-organisms, either before it is laid or af shell is porous, and offers no greater resistance to micro-o which cause disease than it does to those which cause the eg or rot. When the infected egg is eaten raw the micro-org present, are communicated to man and may cause disease. remains in a dirty nest, defiled with the micro-organisms wh typhoid fever, carried there on the hen's feet or feathers, strange if some of these bacteria occasionally penetrate the the egg thus becomes a possible source of infection. Pe of the most common troubles due to bacterial infection of e more or less serious illness sometimes caused by eating th are "stale." This often resembles ptomaine poisoning, caused, not by micro-organisms themselves, but by the products which they elaborate from materials on which the sionally the eggs of worms, etc., have been found inside hens' s indeed have grains, seeds, etc. Such bodies were doubtless tally occluded while the white and shell were being added to k in the egg gland of the fowl.

ged by the comparatively small number of cases of infection or ng due to eggs reported in medical literature, the danger of from this source is not very great. However, in view of its lity, it is best to keep eggs as clean as possible and thus or to prevent infection. Clean poultry houses, poultry runs, sts are important, and eggs should always be stored and mar- nder sanitary conditions. The subject of handling food in a manner is too seldom thought of, and what is said of eggs in nnection applies to many other foods with even more force.

## IMPORTANCE OF THE EGG INDUSTRY.

egg industry is of considerable commercial importance and is increasing. The total number of eggs produced in the United in 1890 was estimated to be 820,000,000 dozen, which would e 13 dozen for each inhabitant of the country per year. ing to the last census report, the total number of eggs pro- in 1899 was 1,294,000,000 dozen, or 17 dozen per capita. In oduction Iowa ranked first with 99,600,000 dozen, Ohio second ,800,000 dozen, and Illinois third with 86,400,000 dozen. The lue of the eggs produced in 1899 was estimated as $144,286,158, rage value of 11.2 cents per dozen. As shown by the census the average values ranged from 8 cents to 34.5 cents per dozen ), being greatest near large cities, in mining districts, and in ctions as Alaska and Hawaii, where the egg production was nall as compared with the population.

**th of the egg industry.**—The United States formerly imported e number of eggs and exported very few. The ratio has d within recent years, and now the exports largely exceed the s. In 1890 the total number of eggs exported was 381,000 worth $59,000. In 1899 it was 3,694,000 dozen, worth $641,000. 3 the exports were smaller, being 1,456,000 dozen, worth 0. In 1890 this country imported 15,000,000 dozen eggs, which alued at $2,000,000, and in 1899 only 225,000 dozen, valued at . In 1903 the value of the eggs imported was much the same, in round numbers, $22,000. An idea of the character and ex- the export trade in eggs may be gathered from the fact that in e United States exported 1,694,000 dozen eggs to Great Britain, at $331,000. For the last six months of 1903 the total number shipped to Alaska was 330,700 dozen, valued at $85,600; to

Hawaii, 64,900 dozen, valued at $14,600, and to Porto Rico, 9,000 dozen, valued at $1,800.

These statistics of the egg trade are of interest, since they show the great growth of the poultry industry and indicate what it may become in the future. Some of the developments may be fairly attributed to the work of the Government and the agricultural experiment stations. For many years a considerable number of the stations, especially those in Alabama, California, Indiana, Kentucky, Louisiana, Maine, Massachusetts, Michigan, Montana, New York, North Carolina, North Dakota, Oklahoma, Oregon, Rhode Island, South Carolina, Utah, Virginia, and West Virginia, have been experimenting upon methods of feeding and caring for poultry, the comparative value of different breeds, the possibility of increasing egg production by proper feeding and the selection of laying stock, and similar problems. The station bulletins reporting the investigations have been circulated widely. These investigations are being continued and promise to be even more valuable in their results in the future than in the past. The Department of Agriculture has done much to encourage the poultry industry by collecting and distributing information,[a] and in other ways.

Poultry raising is often carried on in conjunction with general farming, and may be profitably developed along such lines. When it is followed as an independent enterprise, its possibilities are also great. There is always a market for poultry and eggs for food, while the raising of fancy stock for breeding purposes is frequently worth consideration.

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[a] Farmers' Bulletins 41, 51, 64, 141, and 200 of the Department are devoted exclusively to poultry topics, while 182 treats of the value of poultry as food. A number of Farmers' Bulletins of the series entitled "Experiment Station Work" contain short articles on poultry, poultry feeding, or similar topics. A bibliography of poultry literature has been published by the Department Library (Bul. 18). Bulletin 5 of the Division of Publications contains a list of references to articles on eggs and poultry in the Department publications. A number of the publications of the Bureau of Animal Industry contain articles on poultry diseases, egg production, and other topics, while many of the publications of the Bureau of Statistics give statistics of the poultry and egg industry.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

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# TREE PLANTING ON RURAL SCHOOL GROUNDS.

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REE PL

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WM. L. HALL,

*Assistant Superintendent of Tree Planting, Bureau of Forestry.*

UNITED STATES DEPARTMENT OF AGRICULTURE

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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Hawaii, 64,900 dozen, valued at $14,600, and to Porto Rico, 9,000 dozen, valued at $1,800.

These statistics of the egg trade are of interest, since they show the great growth of the poultry industry and indicate what it may become in the future. Some of the developments may be fairly attributed to the work of the Government and the agricultural experiment stations. For many years a considerable number of the stations, especially those in Alabama, California, Indiana, Kentucky, Louisiana, Maine, Massachusetts, Michigan, Montana, New York, North Carolina, Nor Dakota, Oklahoma, Oregon, Rhode Island, South Carolina, Uta Virginia, and West Virginia, have been experimenting upon m of feeding and caring for poultry, the comparative value of breeds, the possibility of increasing egg production by pr and the selection of laying stock, and similar problem bulletins reporting the investigations have been ci These investigations are being continued and pr more valuable in their results in the future tha Department of Agriculture has done much to industry by collecting and distributing i ways.

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GIFFORD PINCHOT,
*Forester.*

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# TREE PLANTING ON RURAL SCHOOL GROUNDS.

## INTRODUCTION.

A great number of schoolhouses in the United States lack the sur- ndings that make for comfort and contentment. City school unds are often so small that planting is out of the question, though, re space permits, it is not uncommon to find them carefully laid , with a good arrangement of grass plots, flower beds, and shade s. In towns and villages, also, may be pointed out many exam- s showing great care and attention. In the country, however, an roved school ground is rarely found. In hilly, forest regions they often denuded of soil and full of stones and stumps, and on the irie many are well-nigh as bare, bleak, and inhospitable as when y formed a part of the unsettled plain.

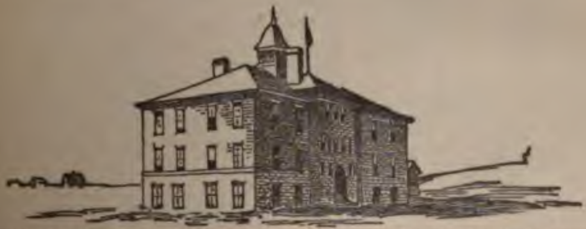

FIG. 1.—A town schoolhouse in a prosperous agricultural region, entirely unprotected.

This lack of improvement is not due to causes evident at first sight. is not on account of poverty, for it is almost as common in wealthy in less prosperous communities. (Figs. 1, 2, and 3.) It is not due lack of appreciation of the elements of beauty, for where homes are rounded with trees, grass, and flowers the school ground is likely entirely neglected. Neither is it due to indifference in educa- affairs, for none [illegible] more cordial in their support of school and institutic [illegible] than the American people. The to lie [illegible] importance of com- in ed [illegible] st of the Amer- the na [illegible] r so far as to willingnes [illegible] and shrubs ntmolested on th [illegible] rant misin- the spirit of [illegible] rstanding of youthful nature, one sees an easily awakened regard for things beautiful and a disposition to respect and help all well-directed activities for the improvement of school life.

## REASONS FOR SCHOOL-GROUND PLANTING.

**Protection.**—The strongest reason for school-ground planting is for the comfort of the teacher and pupils who occupy the building from seven to nine months each year. A schoolhouse so situated as wholly to lack protection from inclement weather often subjects its occupants to distressing conditions. During winter gales there is an increasing demand for fuel, which, though supplied, often does not suffice to keep the building warm. The teacher is then put to test contriving methods by which no pupil shall endure more than his share of cold, and by which to maintain the usual good order during study hours and provide for indoor recreation at the rest periods. With the temperature hovering around the zero point during a howling blizzard, one has but to enter a country schoolroom to appreciate its discomforts and see its need of protection.

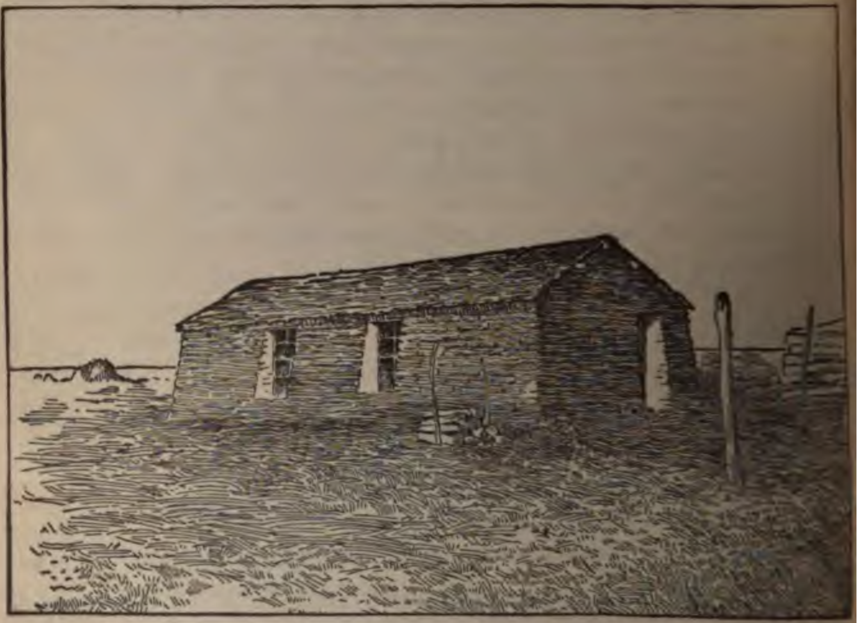

FIG. 2.—Unprotected sod schoolhouse on the Great Plains.

The winds of spring are almost as trying as those of winter, and in summer the sun beats down with unchecked violence. Thus each season is accompanied by ill effects for those who must attend school where the grounds are exposed. The question naturally arises: May ot these conditions be remedied? To this the answer certainly should e that they may. They have been remedied in some instances, and an be in others. It is not too much to say that in nine cases out of en exposed school grounds can be rendered comfortable by trees lanted in wind-breaks.

**Educational Value of Trees.**—But comfort is not the only reason for Planting about the schoolhouse. The trees have also an educational value. Indeed, bare grounds may be regarded as an opportunity. Children interested in the work of selecting, planting, and growing trees and shrubs about the school can gain in the work no little knowledge of right principles and methods. Many people think that to plant a tree all that needs to be done is to dig up a sapling, or buy it, and set it in a hole. This is a great mistake, responsible for many unnecessary failures. Some knowledge of tree culture is a thing sure to prove useful to a large proportion of school children.

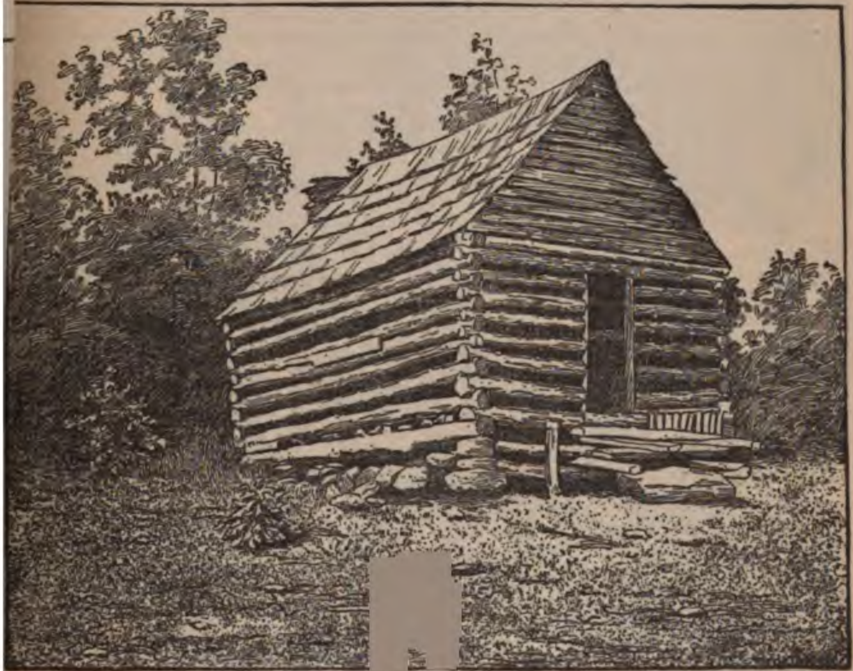

Fig. 3.—Neglected schoolhouse on a forest hillside in the South.

Forestry is beginning to attract attention as a possible subject of school instruction. So far the interest in it is mainly as a branch of nature study, but its growing economic importance may eventually result in its extensive introduction into courses of study. Technical forestry can not be taught in the schools as part of a general education, and *it ought not to* be supposed that tree planting on school grounds looks in that direction. Nevertheless a plantation of forest trees or a wood lot, in connection with a school, would give an excellent opportunity for study of forest growth and management, and in many places it is perfectly feasible. (Fig. 4.)

But there is another side to the educational value of tree planting, which is of first importance. It is money well spent to make the

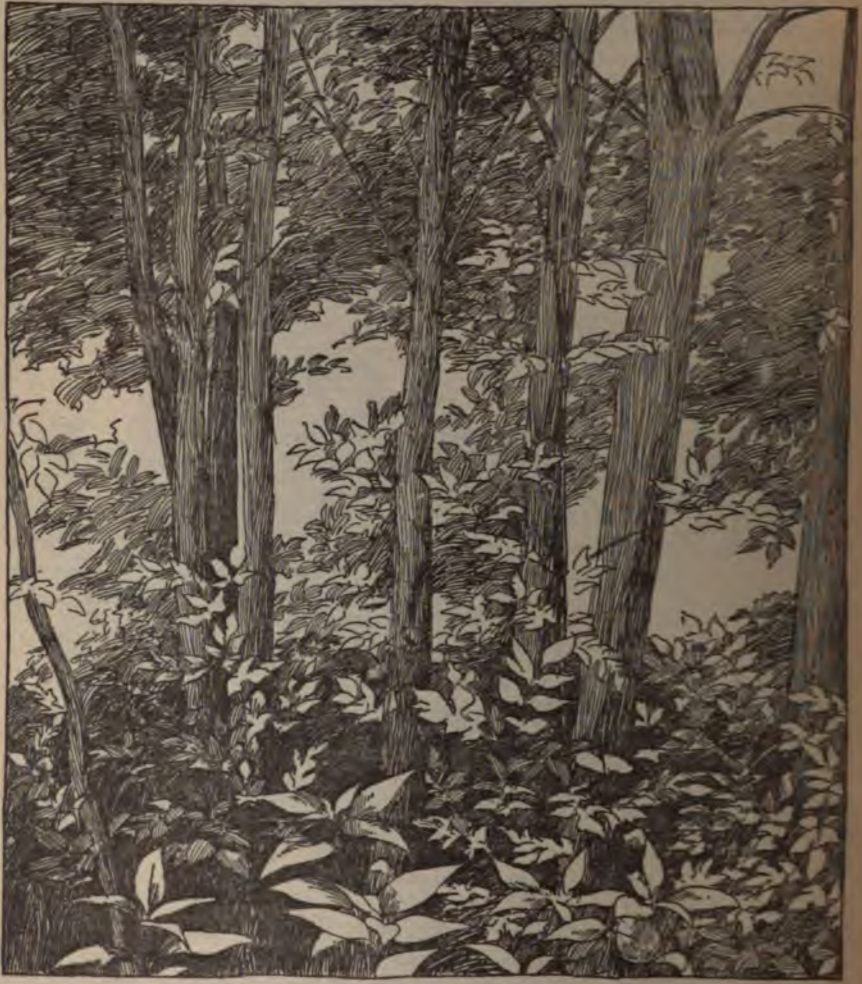

FIG. 4.—Interior of a thrifty forest belt, showing an excellent opportunity to study the growth of trees.

schoolhouse and everything about it attractive and beautiful. Here is one of the centers of the life of the community, the one in which is gathered its most impressionable element. The school is supported at public expense in order to make good American citizens. It aims at securing the highest possible development of mind and character. Every element of order, neatness, and beauty, every broadening influ-e, every appeal to the finer nature of the child means better men l women and a more thrifty, prosperous, and attractive community. nericans are justly proud of their school system, and should be lling to support the schools not only with money, but with time d labor.

## ARBOR DAY AND SCHOOL-GROUND PLANTING.

The neglected condition of the school ground has not remained with-t notice or without some effort toward improvement. The senti-ent in favor of school-ground comfort and adornment has gradually creased for the last thirty years, and has been greatly aided by the tablishment of an annual Arbor Day for tree planting. Arbor Day as proposed by Hon. J. Sterling Morton, ex-Secretary of Agriculture, d was first observed in Nebraska, where it was officially recognized 1872. It was first associated with school-ground planting in Cin-nnati, in 1882, in connection with a meeting of the American Forestry ssociation. Since then it has been best known by its observance in e schools. All the States have followed the example of Nebraska in tablishing Arbor Day, and the movement has now spread into many reign countries. Great Britain, France, Spain, Japan, and New ealand all celebrate their Arbor Days.

**Method of Celebrating Arbor Day.**—The governor of each State nnually appoints Arbor Day at the proper season for planting. This ay is celebrated in the schools by public exercises appropriate to tree lanting, with essays, songs, and recitations by the pupils, and ldresses by visitors. In connection with the exercises there is rdinarily more or less tree planting. Great care is taken to make e planting ceremonies impressive by letting the children take part, nd by planting trees commemorative of noted persons or events. uch more attention is given to these matters than to having the ees in the best condition and to planting them just right.

As might have been expected, the results upon the school grounds ave not been marked. Too often the work has been impulsive and e interest transient. Trees planted with ceremonious dignity in pril have died of neglect before September, and those that survived ave been left to fight unaided their battles for existence. So little ttention has been paid to the choice of trees and to the methods of lanting that those entirely unfit for the situation have often been sed, and have been planted in places where they could not receive rotection while young, or serve any useful purpose when grown. rbor Day has often come on dry, windy days, or clear out of season or planting. Furthermore, the planting has been on too small a cale to be of great benefit. Where an acre of trees in a solid block is eeded, only a half dozen specimens have been planted. After all hat has been done, the school grounds are still largely unimproved.

The educational results of Arbor Day endeavors, however, have been extensive and beneficial. Even though the celebrations have been largely exhibitions of sentiment and the planting almost wholly unsuccessful, yet pupils, teachers, and parents have learned much about trees as useful, living things, and about forests as great sources of national wealth to be protected and perpetually maintained. The smallness of the results has itself drawn attention to the inadequacy of past methods. It is due in part to lessons learned in Arbor Day planting that we are now ready to begin work with a better understanding of what is to be done.

**Necessity for better methods.**—The need of the school grounds is for plantations of hardy trees, cared for by such methods as will keep them constantly thrifty. The trees should be selected and planted in the most careful manner. They should be properly placed, and in sufficient number. To plant in this way requires a great deal of attention to details. It may be the work of several days. The perishable nature of trees also makes it extremely important to plant them when the weather conditions are just right. Dry, windy weather may cause several days' delay in the planting. It is therefore impracticable to depend wholly on a specified day for the work. Let the trees be planted at the right time; then, if public exercises are planned, they may be held on an appointed day after the planting is completed.

Many difficulties at present encountered may be overcome by placing the direction of the planting in the hands of some person who understands fully its purpose. The pupils should assist in the work because it is for their own school ground, but on account of their lack of experience they should work under competent supervision.

## PRELIMINARY ARRANGEMENTS FOR PLANTING.

A movement to improve the school ground is likely to encounter many obstacles. The first, and perhaps the most serious, is public indifference. Then there are the difficulties of getting started on the right planting plan, of finding methods to carry it out, and of having the planted trees properly cared for during both the school year and the vacation period. These are formidable obstacles, as many persons experienced in school-ground planting will testify; yet they have been overcome in a large number of cases, and will continue to be overcome, for every school ground successfully planted will not only induce other districts to undertake the work, but will reveal the methods by which it may be accomplished.

To be of permanent value the planting must be a matter of concern to the whole district. The teacher and the school can not accomplish e work unaided by the parents, neither can the parents accomplish it without the aid of the teacher and the school. Only when all work in unison can the best results be obtained. Unfortunately there are sometimes persons in the district who have no interest in improvement, and it may even happen that they control the school board, while those who have an intelligent interest in the matter may be few in number, and even the teacher may be too deficient in knowledge of planting to give valuable assistance; but such a situation as this is not hopeless if the few persons who desire to make improvements know how to bring things about.

**The Planting Plan.**—The first step is to prepare a plan. This should be a detailed outline of the planting based on a complete analysis of the situation. It should embody a map of the grounds, with the schoolhouse, outbuildings, and place for planting the trees accurately located. If the plan is presented at a meeting in the schoolhouse, a blackboard drawing should be made showing the school ground and exactly what planting is proposed. In this way its advantages can be more clearly pointed out, and its defects, if there be any, will also be pointed out and remedied.

It is scarcely to be expected that a plan will be made which will suit all; so here, as in other matters that concern communities, the majority should rule. It is always to be hoped that the school board, the teacher, and those most active in the improvement of the community will be in perfect accord. If points of difference arise and are not settled after candid discussion, they should be referred to disinterested persons or dropped out of the plan entirely.

**A District Policy.**—While undue haste in adopting a plan should be carefully avoided, it should be remembered that many good movements fail by not being properly prosecuted. If the district adopts the policy of establishing and permanently maintaining a plantation of trees and shrubs on the school ground for ornament, protection, and improvement, a great advance will have been made; but until this has been done there is no guaranty of lasting results. It is easy to arouse the tree-planting spirit in the school, but unless this interest has the support of the district it is likely to wane and languish. The teacher can not take the responsibility, for his tenure of office is liable to be short. Both teacher and school must be among the chief agencies in carrying out the work, but only according to the general plan, judiciously directed by the district authorities. The appropriate celebration of Arbor Day as a part of the plan will aid greatly in the promotion of education and sentiment in tree planting.

As soon as a policy of planting is adopted, some experienced person should be appointed to superintend the preparation of the ground, the procuring of the trees, the planting, and the subsequent cultivation. Such services must usually be paid for, but they are well worth the cost.

## WHAT PLANTING TO DO.

There should be both purpose and method in school-ground planting. The trees must be so arranged as best to serve both for protection and for ornament. At the same time, to grow well they must be adapted to the soil. On a small ground but little planting is possible; a group of trees or shrubs placed where they will look well or hide some unsightly feature of the schoolhouse or ground is sufficient. But in the country there is usually an acre or two of grounds. The schoolhouse is nearly always in the middle, and the playgrounds are usually about halfway between the building and the outer boundary. This arrangement leaves open the outer portions of the ground, where the greater part of the planting is needed.

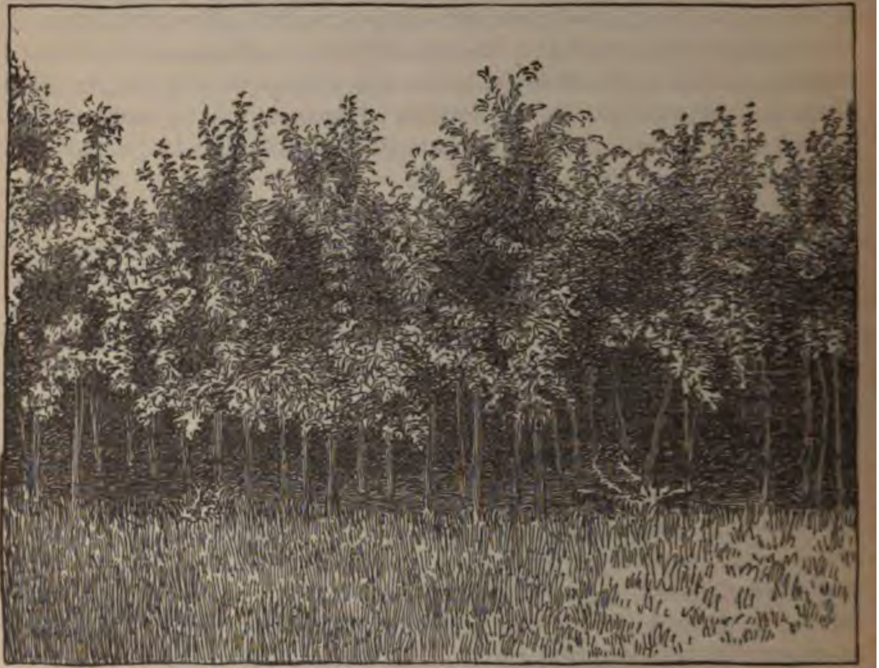

FIG. 5.—A suitable belt for the rear of a school ground.

By so planting, the schoolhouse will be protected on all sides from the wind, while in summer shade will be provided near all portions of the open playground; at the same time inclosing the ground with a border of trees will give a pleasing ornamental effect. Instead of being continuous around the ground, the border should be broken in places to preserve attractive views of the exterior landscape.

The general directions here given may be helpful in affording suggestions, but without modification will seldom be fully adapted to particular cases. The general condition and size of the grounds, direction of prevailing winds, slope, and surroundings should collectively determine the character of the planting.

**A Rear Belt.**—In many cases the first necessity is to plant a belt of trees across the rear of the lot. If the ground is large, this may be several rods wide and cover an acre or more. Possibly it may be extended around the outbuildings so as to hide them from view. Solid planting should be the rule. But it often happens that the rear views from a schoolhouse are quite as attractive as those toward the front. In that case the planting must be planned so as to preserve them, while hiding the unattractive features and giving the necessary protection to the ground and building. Figure 5 shows a good belt of trees for the rear of a school ground, where solid planting is desirable.

**Other Planting.**—After the rear belt, the side planting is of the most importance. Here again the trees should be in belts. To allow room for a playground it may be necessary to make the side belts narrower than that in the rear. Openings in them for walks or views of the exterior landscape may also be desirable, but these need not affect the general plan.

A formal arrangement with the trees in straight rows along the sides of the lot will in many instances be appropriate and satisfactory. It gives opportunity for cultivation, and is both simple and attractive. On large grounds a better effect will often be produced by spacing the trees irregularly. Some attention will be required to leave passages open for cultivation without the trees appearing to stand in rows. The appearance of the entire ground will be improved by varying the width of the belts so that they will project into the interior open space in some places, and in others retreat almost to the boundary of the ground.

The front ground in most cases should not be solidly planted. If it is necessary to hide objectionable buildings and other objects on the front and sides or to prevent the trespassing of stock, either a hedge or an irregular belt of shrubbery may be made to serve the purpose. Two or three groups may be introduced where they will not interfere with the playground or obscure attractive views. Fig. 6 shows an entire front yard shaded by trees planted in regular rows. This is a very poor arrangement, for it shuts off the view and robs the children of their playground.

Where several kinds of trees are used in the belts, they should be mixed by groups and not by single trees. Here will be a group of vase-like elms, there a group of sturdy oaks, yonder one of pines. Such grouping gives character to the planting when seen near at hand, and variety at a distance, where only the tops of the trees are visible, outlined at different heights against the sky.

A little shrubbery rightly used gives a charming effect to a school yard, although many grounds are well planted without it. It finds its place in clumps against the belts of trees, in corners, and in front of objects that should not be in view. Banked against the tall trees the tall-growing forms may be used, but around objects to be screened from view the shrubs should be only high enough to answer the purpose. If planted around the house to hide a rough foundation wall, only low-growing forms should be chosen.

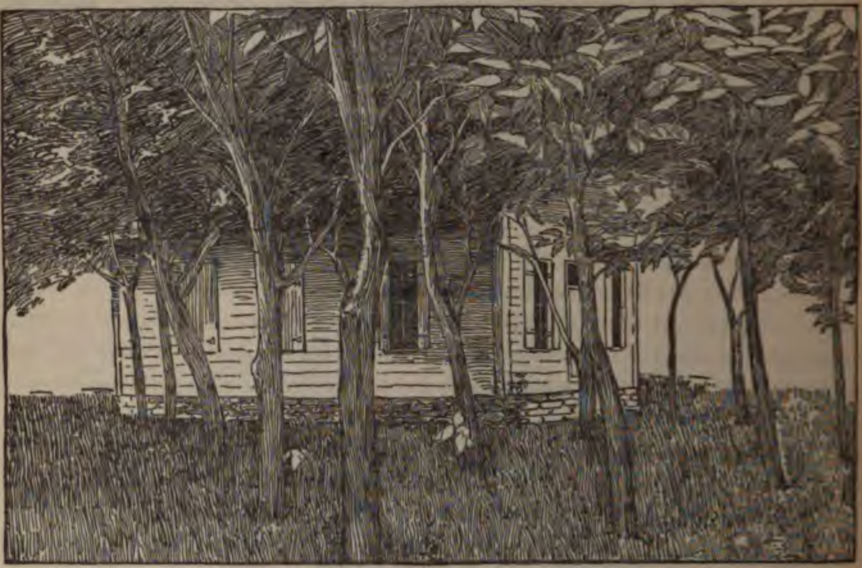

FIG. 6.—Front ground heavily shaded, rear ground open—a poor arrangement.

## KINDS OF TREES TO PLANT.

Persons unskilled in planting are apt to choose inappropriate trees. Fancy leads them to use odd kinds and to form grotesque combinations which fulfill none of the purposes of planting. Besides, the use of such trees is likely to be very costly on account of the high prices charged for them and the labor required to make them grow. Fortunately, the best trees for planting are easily obtained, because they are usually those common in the locality.

**Hardy Trees.**—The first rule to lay down is to plant only the kinds that are known to be hardy. A school-ground plantation is no place for experiment. Naturally the trees will have to endure greater hardships than those of a private plantation; they will be likely to have less cultivation and be subject to more abuse. No matter how strict the rules, the soil about them will be more or less trampled, and twigs will sometimes be broken from their tops. Any tree that can not endure moderate abuse of this kind should not be given a place on the school ground.

On account of difference in the soil, a tree that thrives in one place in a locality may not thrive in another place. Sandy soils and clay soils are often found near together, and trees that grow thriftily in sandy soil may have a hard struggle to exist when planted in clay. For this reason both the soil and the subsoil of the school ground should be carefully examined, and a list should be made of trees in the neighborhood that are thriving on soils of the same character, and no other species should be used. Much better success may be expected with a soil and subsoil of a porous character than with one that is tenacious and impenetrable. Yet a careful study will show numerous species adapted to each kind of soil.

**Trees Easily Obtained.**—Elms, oaks, and maples are to be had almost anywhere, and are easily transplanted. They are as beautiful as any trees to be found, and are in every way well adapted for the school ground. They grow on a great variety of soils, and can be easily raised from seed if young trees are not available. Every region will afford other valuable sorts, such as beeches, chestnuts, walnuts, ashes, pines, or spruces. From these and such other desirable kinds as the locality affords the selection should be made.

**Short and Long-Lived Trees.**—The school ground being permanent and the need of trees continuous, for the most part long-lived trees should be used. But where the present need of trees is great, there is another side to the question. A short-lived tree grows quickly, coming into early usefulness, and serves its purpose for from twenty-five to fifty years. A long-lived tree usually grows more slowly, but serves its purpose for a century or more. In many cases it is advisable to use the two kinds in such a way that the long-lived trees will become useful about the time the short-lived trees reach maturity. The latter can then be removed, leaving the ground to the long-lived trees. In all cases an ultimate stand of such trees as elms, oaks, walnuts, or chestnuts should be the aim.

**A Variety of Species.**—It may seem that the number of kinds which can be used for school-ground planting is small, but this is not the case. In almost all sections of the country a long list of species fully adapted to the purpose can be made out. In selecting among these the aim should be to give the plantation as much variety as possible, since among other purposes it is to serve that of instruction.

## OBTAINING THE TREES.

**Forest Seedlings.**—In many places trees can be obtained from the neighboring forest, from the banks of streams, from plantations, or even from open fields. If they have had normal conditions of gr are taken at the right time, they are almost as valuable for planting as nursery-grown seedlings. Pine, spruce, and cedar are to be collected in unlimited numbers in many forests, and frequently ash, maple, and elm are almost as abundant. They may be gathered either in the fall or spring, but unless they are very carefully heeled in and protected over winter the better time is early spring. In collecting forest seedlings only the small trees that have grown in the light should be taken, as these are more likely to be young and vigorous than those grown in the shade. The collector should never pull the trees from the ground, but should dig them carefully with a spade, preserving as much of the root as possible. As each tree is dug it should be placed in a barrel containing water until all are collected, when they may be heeled in together, as described for stock purchased from a nursery (page 22). The pupils will be eager to enter into this part of the work, and, under the direction of the teacher or superintendent f planting, they can do it as well as anyone. It will be a pleasure to em, and the knowledge gained will be valuable.

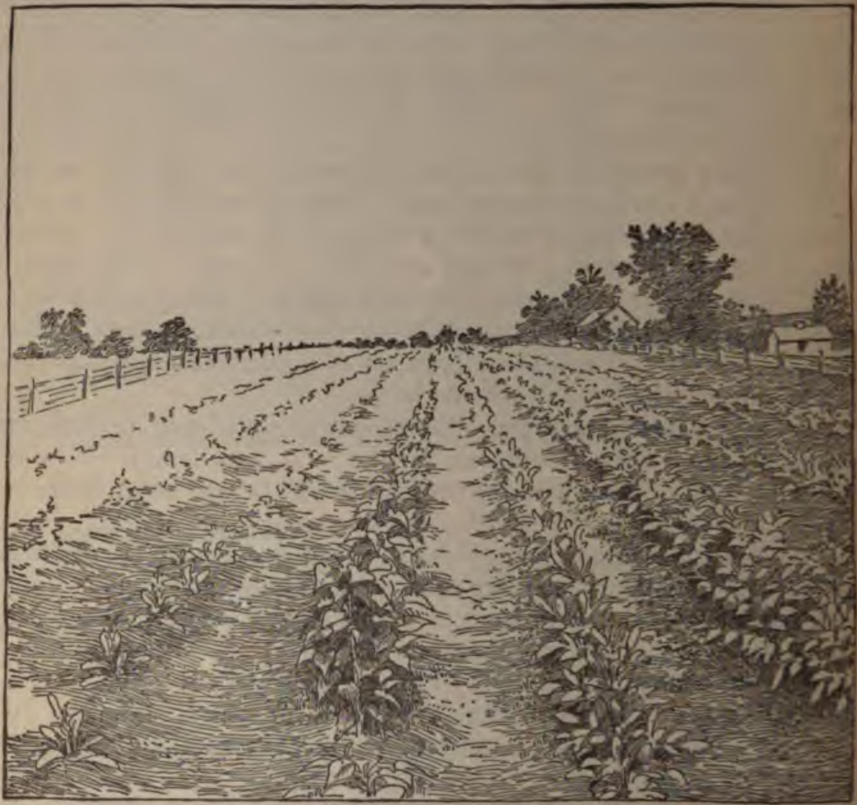

Fig. 7.—A small forest tree nursery.

**me-Grown Seedlings.**—If wild seedlings can not be collected and it t convenient to buy the trees from a nursery, it will be necessary ow them from the seed. This method has the advantages of being mical and of supplying the stock exactly at the time needed. It easy matter to grow forest seedlings, and to one who likes trees a pleasure. The superintendent of planting should arrange to the seedlings grown by some reliable person, and it will be help- have the school children assist in gathering and planting the . (See fig. 7.) If grown from seed, rees will usually need to remain in the ry only one or two years. Just before for planting they should be taken up eeled in so that they will be in readiness wanted.

**es from a Nursery.**—The most common od of obtaining forest trees in regions te from the natural woodland is to pur- them from a nursery. Nearly all ries grow trees for ornamental plant- nd a number in the prairie States offer for forest planting. Where large ties are handled, the trees are usually seedlings when one or two years old, quoted by the hundred or thousand, e for ordinary kinds ranging from $2 er thousand. Ornamental trees are the age of from three to five years, ving been transplanted once or more. e sold by the single tree, or in small es, at prices ranging from 10 to 25 ch.

rule there is little to be gained by large trees. If only a few are to ted and the best of care can be given rees 8 or 10 feet high, or even larger, used, and are much less likely to be d after planting; but if a number are ed, smaller trees are better. Besides costing much less, they ot so bulky, and are, therefore, less expensive to ship, less diffi- o plant, and are always transplanted with greater success than r ones. Fig. 8 shows a good size. This tree is two years old 36 inches high.

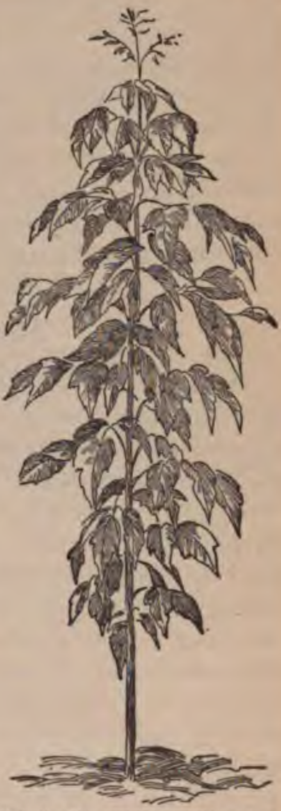

FIG. 8.—Box Elder seedling, two years old, 36 inches high, showing a good size for planting.

e trees should be on hand as soon as the freezing is past in the g. To insure delivery at the proper time, they should be ordered r three months beforehand. It is usually best to order from a nursery in the same region, and, if possible, one which can ship over a single line of railroad. Every precaution should be taken to prevent delays in shipment and transit, and the receiver should be ready to care for the stock when it arrives.

As soon as the trees are received, they should be unpacked and prepared for heeling in by placing the roots in a thin mixture made by stirring together earth and water. They should remain in this while a trench is being dug, deep enough to bury the roots and about half of the tops. It should extend east and west, with its south bank sloping at an angle of about 30° with the surface of the ground. In this is placed a layer of trees, with their tops leaning south and their roots and trunks covered and well packed with fresh fine earth taken out on the north side of the trench. In the trench thus formed on the north side of the first layer is placed a second layer, with the tops leaned over on the first and covered in the same way. This operation is continued until all the trees have been heeled in. They should be left in this condition until the time of planting.

## HOW TO PLANT THE TREES.

**Preparation of the Soil.**—Thorough preparation of the soil should precede the planting. Where blocks or belts are to be formed, the ground should be plowed and prepared as for a garden crop. Clay soils are best plowed the previous fall, in order that the ground may weather over winter. On such soil subsoiling is beneficial, and should precede the planting by at least one season. Just before planting time the ground should be pulverized with a roller or harrow. If the planting is to be done in rows, the ground should be marked off lengthwise and crosswise and the trees set at the intersections. It is sometimes desirable to mark off the ground only one way and run furrows the other. In arid regions the furrows may be deepened into trenches, so that rain water which falls on the surrounding ground may be drained to the tree. On the other hand, in regions having a copious rainfall it will frequently be necessary to plant the trees on a raised portion or mound of earth in order to keep the soil dry enough for them to thrive. The holes should be dug large enough to contain all the roots fully spread out, and deep enough to allow the tree to stand about 3 inches lower than it grew as a seedling.

**Time and Manner of Planting.**—South of the thirty-seventh parallel, fall planting is safe and often advantageous. North of this, spring planting should be the rule, as fall-planted trees can scarcely develop sufficient roots to sustain themselves during the winter. The most successful nurserymen practice early planting for deciduous trees, beginning operations as soon as the ground ceases freezing. Evergreens are not planted until later; some even wait until the young growth is starting. If possible, planting should be done on a cool, cloudy day. Unless the day is very moist, the trees should be carried to the planting site in a barrel half filled with water, or a thin mixture of earth and water, and lifted out only as they are wanted. Even a minute's exposure to dry air will injure the delicate roots—the feeders of the tree.

The roots should be extended in their natural positions and carefully packed in fine loam soil. It is a good practice to work the soil about each root separately and pack it solid with the foot. As the hole is filled, the earth should be compacted above the roots and around the stem, in order to hold the tree firmly in place. The last 2 inches of soil should be very fine, and should lie perfectly loose. It will serve as a mulch to retain the moisture.

Trees should be planted neither in very wet nor in very dry soil. If the soil is wet, it is better to wait until it is drier. On the other hand, if good cultivation has been maintained the year previous to planting the soil is not likely to be so dry that trees will not start. Besides insuring a supply of moisture, such cultivation puts the ground in good physical condition for planting.

With this treatment watering will scarcely ever be necessary. If it is, the holes may be dug a few days beforehand and filled with water. They should be refilled as the water soaks away until the soil is fully moistened. A thorough irrigation, when that is possible, is still better. As soon as the soil becomes somewhat dry the trees should be planted. While it is a common custom to water at the time of planting, those who do no watering are usually the most successful. Even in the semiarid regions some successful growers apply no water, but keep up an excellent system of cultivation, thereby retaining the soil moisture.

The spacing of the trees is not so important in school-ground planting as in forest plantations, yet it is worth consideration. The trees should not stand so near together as to produce long, slender poles; on the contrary, short, thick trunks are desirable, to support large tops and withstand heavy winds. From 8 to 12 feet apart will be suitable spacing distance. Where large blocks are to be planted the trees may be closer, but it is scarcely ever desirable to plant them closer than 6 by 6 feet.

## WHY TREES DIE IN TRANSPLANTING.

To many persons it is a mystery why trees die after being transplanted. They do not die without cause, however, and when one begins to wither something is wrong. Oftentimes the result is not to be noticed until weeks after the injury; in other cases it is apparent in a few days. After the injury has been done it can be only by the subsequent growth of the tree. All the assistance that can be given is to make the surroundings of the tree favorable for growth. The following are some of the causes of death among transplanted trees:

**Loss of Roots.**—The loss of the principal part of its root system when the tree is being taken up is a great shock to its vitality, and frequently causes its death. A very large part of the root must be cut off, for usually the space surrounding the tree is filled with fibrous rootlets, myriads of which can scarcely be detected with the naked eye. Almost all of these are lost, as well as many of the larger roots. Mr. D. C. Burson, of Topeka, Kans., last year dug up and measured as much as he could of the root system of a vigorous Hardy Catalpa seedling that had grown from May till November. This six-months-old seedling showed over 250 feet of root growth. By the methods in common use only a fifth, or perhaps as little as a tenth, of the root is taken up with the tree in transplanting. Such loss throws the root out of balance with the top. If the top is not shortened, or in some way protected, the leaves may evaporate more moisture than the roots can provide, resulting in the death of the tree.

**Exposure before Planting.**—With proper subsequent treatment a tree can endure the loss of many roots, but instead of the needed protection it often gets much unnecessary exposure to sun and dry air. This may be in digging, packing, shipping, unpacking, or any other of the various handlings which it undergoes between its removal from the ground and subsequent planting. On a warm day in March the writer saw a bundle of trees in shipment across the plains of Texas without the slightest covering. Before the destination was reached the roots became withered and almost dry, having suffered a hundred times more exposure than the ordinary tree can stand without injury. Not many persons would be guilty of such gross neglect, but the fact remains that exposure causes the death of more trees in transplanting than any other single cause. Exposure can usually be easily prevented, and no one who persists in neglectful practices can hope to be successful.

**Failure to Plant Well.**—The failure to pack the soil tightly about the roots is a common error in planting. It causes injury in two ways: It leaves the tree unstable, to be rocked to and fro or even blown down by the wind; it also prevents the first growth of rootlets from absorbing food. This they can not do unless good, fine soil is firmly packed around them. Clods will not pack snugly. Likewise manure or litter of any kind mixed with the soil may prevent firm packing. Anything that prevents the soil particles from coming into close contact with the roots is sure to be injurious. Another error is in shallow planting. This allows wind and water to lay bare the roots, and in a short time the tree dies. Crowding the roots into too small a hole is a similar

culty. Such errors are more often due to lack of experience and
l than to haste. The unskillful planter will hardly plant well, how-
r slowly he may go.

**Wet Soil.**—Trees are often injured by being planted in wet soil.
ether the excessive moisture is a permanent or a temporary con-
on is likely to make little difference in the results. If it is perma-
t the water prevents the air from reaching the roots, while if it is
y temporary the trampling of the soil over them causes it to stick
ether so that on drying it becomes baked, leaving them impacted
hard lump of earth which excludes the air. Excessive air cur-
ts in the soil are injurious by drying the roots, but a constant per-
tion of the soil by the air is necessary to supply oxygen. This
cess is precluded by either the saturation or the baking of the soil.
drained pockets occur here and there even in well-drained fields,
are always difficult to deal with in tree growing.

**rying Out of the Soil.**—Another cause of death is the drying out of
soil. Summer droughts are not unknown in any part of the
ntry, and are very frequent in parts of the Mississippi Valley and
the Plains. Occasionally they are so intense and long continued
it is difficult to make recently transplanted trees survive, even
n carefully planted and cultivated. In such a time, those which
poorly planted and cultivated are almost sure to die. Frequently,
weeds and grass grow up in the plantation and draw off the
sture, thereby greatly diminishing the supply for the young trees.
n a school ground there is likelihood of the trees being injured by
trampling of the soil. The pupils will naturally wish to play
ng them, and unless they are restrained the soil will soon become
pacted. It then dries out very quickly, and in time of drought
trees are sure to suffer, and may be killed.

## CARE OF TREES AFTER PLANTING.

**ultivation.**—Important as the process of planting is, one can never
ertain that a tree planted with the greatest care will live and reach
urity. Much depends upon the after-treatment. In many parts
the country cultivation is absolutely essential, and nearly every-
ere a tree will thrive better and grow faster during its early years
th cultivation than without it. The purposes of cultivation are
inly to protect young trees from the encroachment of weeds and
ass, to keep the soil in good physical condition, and to retain the
oisture. Good cultivation is that which serves these purposes with-
ut injuring the trees. It does not necessarily include deep tillage.
fact, deep tillage may be positively injurious by breaking off the
eding roots, and is usually not necessary to loosen the soil. Very
w soils are too hard for tree roots to penetrate if moisture is plenti-

ful. The best way to retain moisture is by frequently stirri
soil to a depth of 2 or 3 inches. The longer cultivation is cont
the better will be the effect upon the trees. It should not c
any case until they are well established and prepared to thrive w
further attention.

Scattering or isolated trees can not usually be cultivated exce
occasionally spading up the earth within a circle of a few feet a
them. This is necessary in order to keep the grass and weeds
crowding them and retarding their growth.

The difficulty in tilling a school-ground plantation will come d
the vacation period. That is the busy time of the year, when
must be tilled and harvests reaped. Unless the person in cha
very watchful the plantation is sure to suffer.

**Increasing the Moisture Supply.**—Although artificial watering
recommended, it is necessary to keep the soil of the plantation
erately moist. Sometimes a great deal of moisture can be adde
conducting to the plantation the water that drains from adj
slopes. A small trench made to correspond with the contour li
a hill or slope will often gather almost all the surface-drainage
In the Northwest, trees planted as snowbreaks a few rods fro
north and west sides of the plantation will cause the drifts of s
form just outside of the plantation. The trees will thus be saved
breakage, and a helpful supply of moisture will be added at the
of the plantation.

**Pruning.**—Within a few years after planting some pruning
necessary to remove the broken and useless branches and corre
tendency toward crookedness. Much pruning should be done
the trees are young, because the wounds made then are small a
quickly heal. Also, very much less labor will be required to
at this time than later, because the branches which can be re
with a knife or pruning shears on a two-year-old tree will have
removed with an ax or saw a few years later. The plantation
be pruned about every third year, but if careful attention is gi
pruning when it is young, very little later work will be req
The best season is late fall or very early spring. Good p
requires care and skill. The best work is done with pruning
pruning shears, and saw. The branches should be cut off close
trunk, leaving no projecting stub or shoulder. The brush sh
taken out of the plantation and burned as soon as dry.

**Protection of Trees from Injury.**—The responsibility will
upon the teacher to inculcate a spirit of respect on the par
pupils for the plantation. The best way to do this is to mak
feel a responsibility for its success. If they feel a personal
it, there is little danger of their giving the trees rough usage
ing or breaking them.

n some rural districts where danger of injury from trespassing k is not overcome by an ornamental hedge or by the grouping of bbery, as mentioned in connection with the planting, the grounds ld be inclosed by a fence. A paling or a fence of woven wire answer the purpose.

## DIES FOR THE TEACHER AND SCHOOL.

thrifty plantation of trees or a dland lot presents a field for ed and important observation, h the teacher experienced in enting topics of nature study know how to appreciate. No- e can better illustrations be d of the operation of many im- ant biological laws, and the les- learned here are sure to be mbered, because, once grasped, examples of the same phenom- re certain to be constantly pre- ed to the awakened attention of oy or girl.

**aracteristics of Trees.**—Naturally of the first lessons in this forest k will be to study the different s of trees, and to learn the char- ristics which separate them into ups; for example, the points of erence between conifers and broadleaf trees, beween oaks and ples, and even between one kind of maple and another.

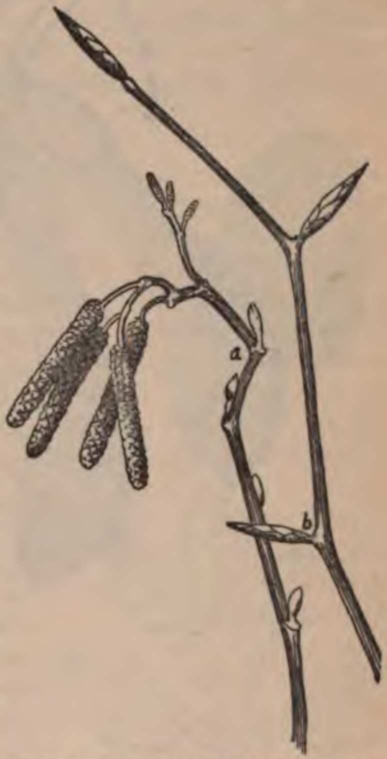

Fig. 9.—Winter condition of twigs and buds: *a*, Smooth Alder; *b*, Beech.

rominent among the distinguishing characters of trees are their twigs, buds, leaves, flowers, and seeds. Great variation will be found, variation not only in trees of different kinds but in the same tree at different seasons. The summer and winter conditions of twigs and buds of deciduous trees are so different that one can scarcely tify a tree in winter from a knowledge of its summer appearance. . 11 shows the *winter condition* of twigs and buds of Smooth Alder

10.—Twig of Horse Chestnut, showing leaves and annual growth.

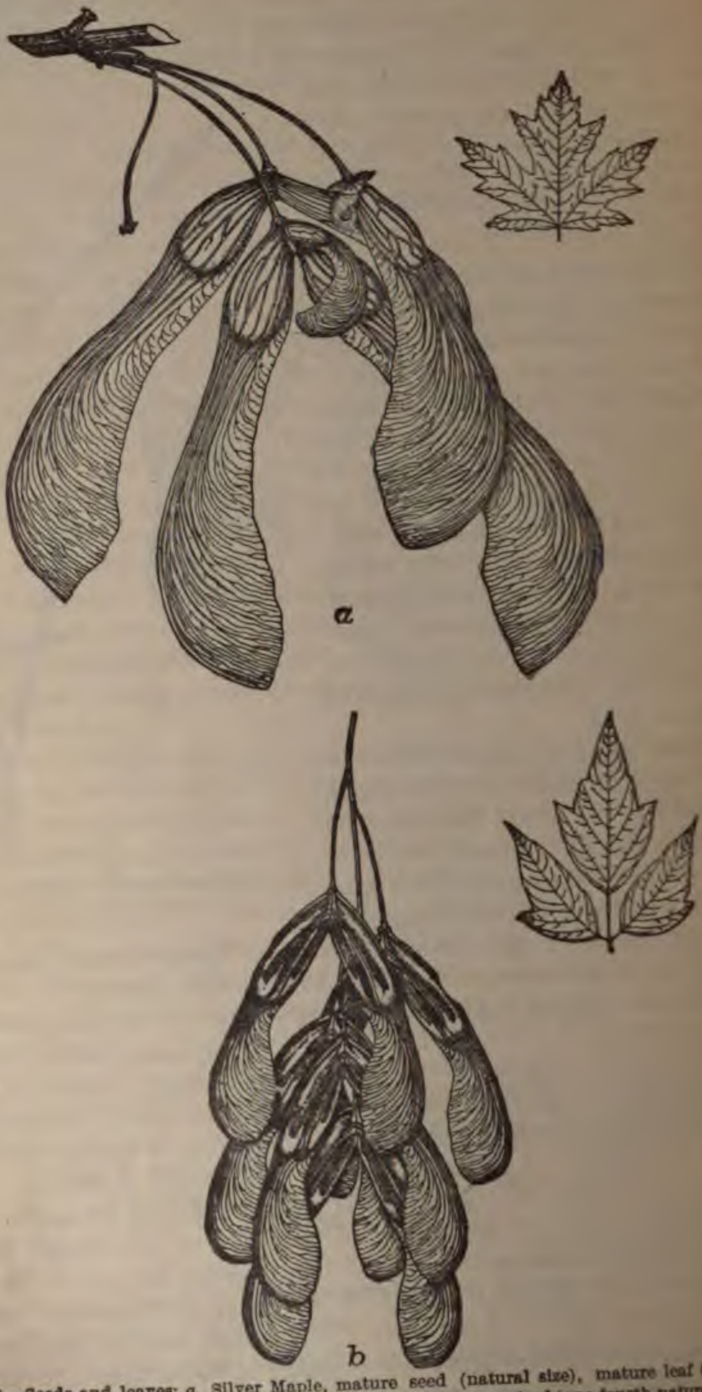

FIG. 11.—Seeds and leaves: *a*, Silver Maple, mature seed (natural size), mature leaf (one- natural size); *b*, Box Elder, mature seed (natural size), mature leaf (one-fourth natural si

Beech; fig. 10, the twig and leaves of Horse Chestnut. In study seeds it is important to notice such points as how they are borne, r structure, shape, size, time of ripening, and means of dissemina- . Figs. 11 and 12 show the seeds and leaves of Boxelder, Silver le, and White Oak. Fig. 13 shows the late winter condition corns after having begun to germinate the previous fall, while 14 shows theircondition after a few warm spring days have ed.

**fluence of Soil upon Trees.**—The study e soil preferences of trees is impor- because from it we gain a knowledge e of the chief factors in tree growth. this study it is best, if possible, to go e natural woods, for there will be the results of many years of struggle g numerous species with no help man to aid the growth of one tree tard that of another. Under such tions, when one species establishes to the exclusion of all others, it may ly be inferred that this species is r adapted to the situation than any s rivals. This should be kept in as one notes the willows and alders ng in low, wet places, the Chestnut White Oak upon gravelly ridges, or hange from the broadleaf to the co- ous forest between the base and sum- f a high mountain. If the school is ear a natural forest or a mountain, light forest growth along a stream, en a plantation, will afford the teacher opportunities for investigations of ar character.

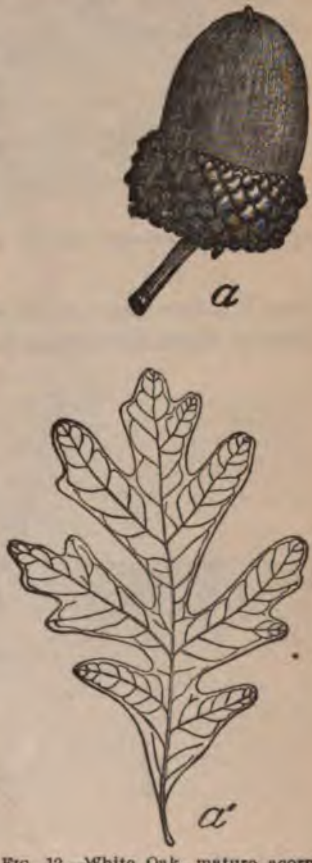

FIG. 12.—White Oak, mature acorn (natural size), mature leaf (¼ natural size).

**nposition of Soils.**—It is desirable that y teacher should know something t soils. He should be able to distin- h a soil as sand, loam, marl, or clay, and know something of the ation of each, and of its capacity to absorb and retain moisture and . Not only the surface soil, but also that part which lies hidden w, the subsoil, should be examined, for both have great influence n the growth of a tree. Most trees send their roots deep into the and, and if their course is retarded by a tenacious layer of clay or mpermeable layer of stone, the tree will not attain its full growth development. Then, it will be found that one kind of tree thrives on sandy soil, and another kind on clay soil; that one flourishe sunny exposure, while another does best on a shaded northern

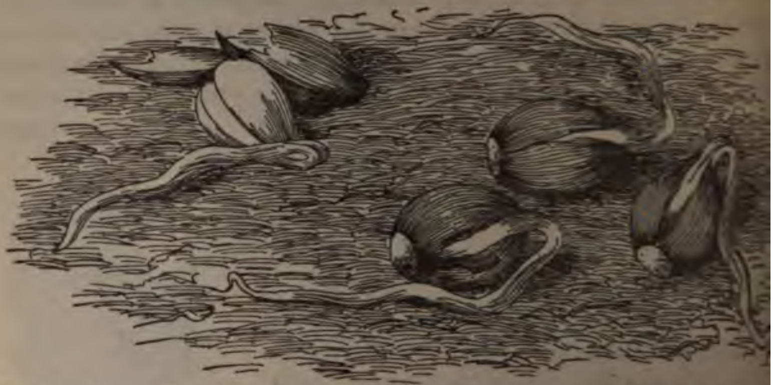

FIG. 13.—Acorns collected beneath a cover of leaves in February. Germination had be previous fall.

here is a tree that grows well only where the soil is deep, porous fertile; there is one that seems satisfied on the poorest gravelly

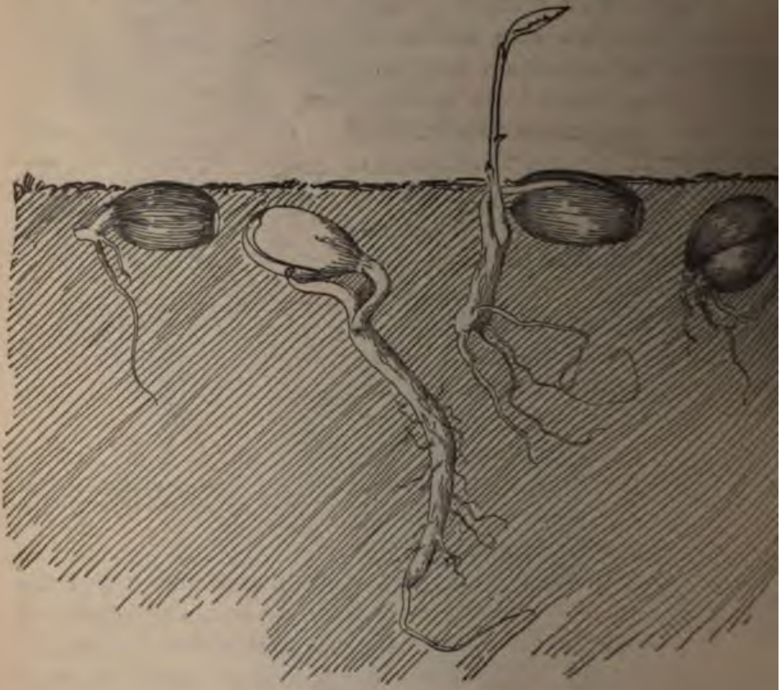

FIG. 14.—Germinating acorns in early spring.

**Influence of Trees Upon Soil.**—While the soil has a great i upon trees, it is also true that trees have a great influenc soil. Selecting a spot where large trees stand closely crowded ther, one may rake aside the thick layer of leaves and see that it kept the soil moist by preventing evaporation. He may notice, that the lower leaves of the layer are wet and moldy. They are nning to decay. Among them are pieces of twigs, cones, and s of nuts. All are blackened and appear to be turning to soil. w this layer is another of the same material, but still more like and in it is a dense tangle of living rootlets of neighboring trees shrubs. If this soil is examined closely, it will be found that it is ike the soil of long-cultivated fields, composed of small pebbles

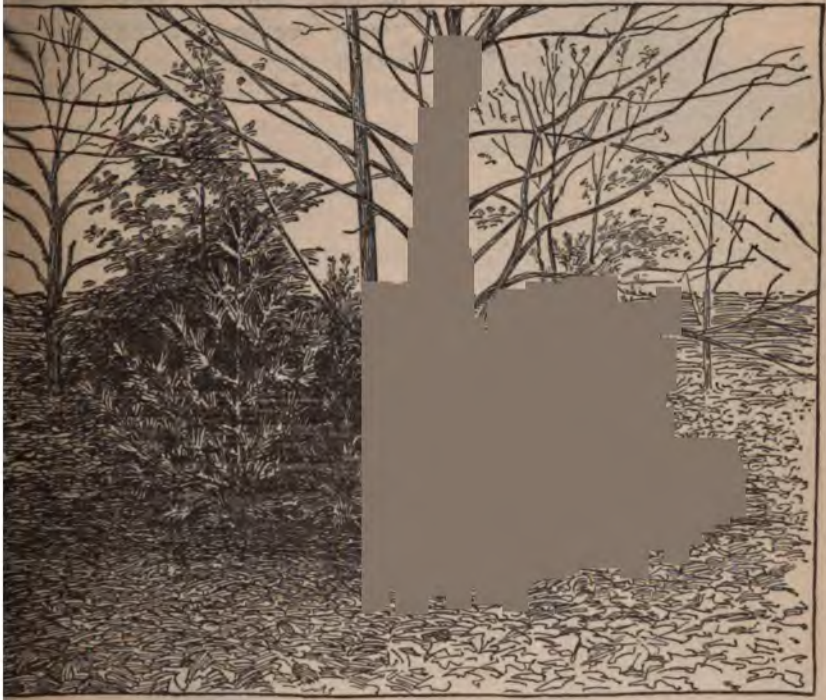

FIG. 15.—White Pine under the protection of Chestnut.

grains of sand, but is made up mostly of decayed leaves, wood, nuts. Deeper down, this vegetable mold becomes less, and granr particles appear in greater abundance, but it may not be possible see any but the most gradual change from one to the other. On ging far down into the subsoil one constantly cuts through old aying roots.

Thus trees are constantly returning vegetable matter to the soil m which they grow. They add to it the mold which gives it its k color, its power to absorb and retain moisture and heat, and, in arge degree, its porosity and fertility. A dense cover of trees will time *transform the poorest soil* into a fertile one.

**Influence of Trees upon One Another.**—Trees are often depe one another in their germination and growth. In fig. 1 White Pine seedlings are coming up under the sheltering bra a Chestnut. It gives them an increased supply of moisture an shade, and nowhere else near by have they come up in su dance. Such is frequently in the forest. The tender require the protection aff the older trees. There is, l another phase of this in matter. Within a few y young seedlings reach th where they require the from which they needed p when young. Then the san topping trees that sheltered their infancy become a m them. In many cases they grow a few years and die. Now s one finds a gap among the tree tops and grows up to occupy it, b itself a dominant tree in the forest.

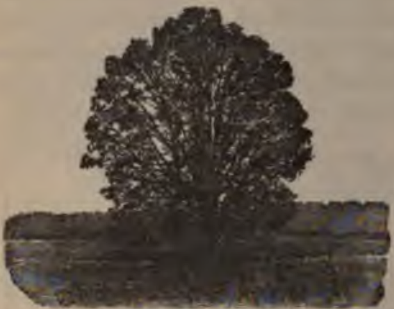
FIG. 16.—Oak grown in the open.

The density of trees greatly affects their growth. The isola grows with a short trunk and spreading top, while the crow produces a long, slender trunk and narrow top. The difference in form is caused by the effort of the tree to present its greatest extent of leaf surface to the sunlight. Where it stands alone, this is accomplished by the top assuming a spreading or rounded form, but where it is crowded by others and shaded on all sides, it can reach the sunlight only by pushing upward and overtopping its rivals. Hence there is a continual struggle among crowded young trees in their upward growth, and as they grow their lower branches become more and more densely shaded until they die. Decay follows, and soon they drop off, leaving the trunk clear of branches. Fig. 16 sh extreme form of an isolated tree, while fig. 17 shows the upright growth of a tree grown in a forest. Each form has and use—the spreading tree for shade and ornament, and the unbranched tree for lumber.

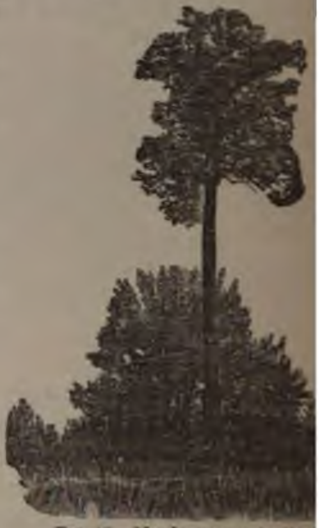
FIG. 17.—Maple grown in the

**oks and Trees.**—For the most part, a knowledge of trees can best
btained from the trees themselves. There are some things, how-
, that can be more easily and rapidly learned from books: First,
an learn best from books the important things to look for, or
to study; second, many inaccessible kinds must be studied from
s or not at all; third, there are some things about trees that can
ore readily learned from books than from experiment, such as
to handle, transplant, and cultivate them.

owledge will be gained much more quickly, and will be more
rehensive and much less likely to include erroneous notions, if
ned not alone from the natural objects, but in part from the best
s on the subject. So, in silvicultural studies, that teaching will
ost valuable that leads the pupil into both original investigation
he study of books.

## FACTS ABOUT TREES.

e **Processes.**—Trees are living things with vital functions and
They have systems of digestion, assimilation, and respiration,
specialized organs for carrying on the various processes, much
me as animals. In correspondence with most of the vegetable
dom, their leaves have the power under the action of sunlight to
b carbonic acid gas from the air, to break it up, and, with the
n obtained and water, to form starch. The oxygen is returned
e air unused. The water comes directly from the soil through
roots and stems, and carries in solution mineral compounds which
r into combination with the starch, forming the more complex
pounds such as the tree can readily utilize. These are drawn away
he branches, stem, and roots, there organized into living substance,
made a part of the tissues of the tree.

o carry up the supply of minerals from the roots to the leaves, much
e water is required than the tree can utilize in the formation of
ch. The excess passes off as vapor through the pores of the leaves
the atmosphere, by a process of transpiration.

tree breathes for the same purpose as an animal. It takes in
gen and throws off carbonic acid gas. The process is not centered
special organ, but goes on over all parts of the leaves, branches,
roots. In the leaves the breathing goes on through the pores; in
s of the tree covered by bark it goes on through the lenticels—the
ll, light-colored, raised spots plainly seen on the young branches
early all trees. Breathing is an entirely separate process from
by which carbonic acid gas is taken in through the leaves and
gen liberated. It goes on both day and night and at all seasons of
year, though more rapidly in summer than in winter.

**Life History.**—A tree has a definite life history as an organism, with periods of growth, maturity, and decline, and characteristic development in matters of form, structure, and size. There is marked difference in the rate of growth of different trees, and even of the same tree at different ages. Most of the pines grow very slowly for the first ten or twelve years, but much more rapidly after that. Other trees, such as the Tulip-tree, grow rapidly for forty or fifty years, and then more slowly. Still others, such as the oaks, have a very regular rate of increase throughout the growing period. Great variation exists in the age at which trees become mature. While some reach maturity at the age of fifty or sixty years, many of the most valuable commercial trees become mature at from one hundred and fifty to two hundred years. The Redwood of California often is not mature before the age of a thousand years. A tree will continue to make some growth through its maturity and decline, though during its maturity its height growth has almost ceased and its diameter growth is slow. Decline begins when the destructive forces exceed the growth forces.

Given the same climatic and soil conditions, one tree will assume one form, another a form very different. The beech will form a round, much-branched top, the Red Cedar a slender tree with a central stem. The oak will reach majestic proportions, the dogwood will become nothing more than a shrub. The hickory will form heavy, elastic wood, the birch that which is light and brittle. The pine will yield resin and turpentine; the oak, tannin; the maple, sugar. Th each tree preserves perfectly its identity in external form and internal structure and composition.

**Reproduction.**—A tree reproduces either by seeds or buds. I nature, reproduction by seeds is more common, although reprod tion by buds is quite as regular as by seeds in some species. Th tendency of the locust to sprout from the roots and of oaks to re growth from the stump are examples of bud reproduction. The f ester in handling woodlands depends upon both methods. Such tr as reproduce only by seeds he keeps by leaving seed trees dis uted over the land when the crop of timber is cut. Those that rep duce from buds renew their growth from the stumps of the cut tr Not only does bud reproduction take place when the buds are attac to the parent tree, but also when they are separated from it. A may be divided into many parts, each part becoming a new individ This gives rise to propagation by cuttings, grafts, and buds. M forest trees can be propagated by cuttings, and nearly all can be gr and budded.

**Food.**—In harmony with all other living things, trees require fo Their food is composed of the carbon obtained from the air, and water and mineral compounds obtained from the soil. Carbon, gen, hydrogen, nitrogen, magnesium, calcium, iron, sulphur, p

us, potassium, and chlorine are called essential elements because,
trees as with all other plants, their presence is necessary to
t. Other elements are absorbed when present in the soil in solu-
orm, but their absence causes the tree no loss in vigor. The ele-
s are not absorbed separately and alone, for they rarely exist in
condition, but are blended together with one another into com-
ds. Thus, in water the plant obtains both hydrogen and oxygen.
sium, nitrogen, and oxygen are often united in the form of
sium nitrate, a valuable plant food.

**ubility of Plant Food.**—Trees are able to absorb the mineral com-
ds only as they are in solution in the water taken up by the roots.
compounds of the soil which contain valuable food elements are
ble in soil water, and therefore unavailable. Thus, while potassium
essential element, it may be in such combinations with aluminum,
n, and other elements as to be insoluble and useless. Chemical
ges are slowly going on in the soil by which insoluble compounds
onverted into soluble compounds. Cultivation and fertilization
n such changes, and to do this is one of their chief purposes.

**ntity of Food.**—When the food of a tree is in available form, the
er the supply the more rapid its growth. Fertile soil has an
lance of food materials, with the result that a tree situated upon
ows rapidly. Sterile soil is deficient in food materials, conse-
ly a tree situated upon it grows slowly. The same cause,
her with the conservation of moisture, explains the difference in
th between cultivated and uncultivated trees upon the same kind
l. The cultivated tree, with its larger store of food and moisture
ts protection from the competition of weeds and grass, rapidly
rips its less fortunate neighbor.

**entials to Growth.**—A tree can grow only when supplied with air,
moisture, and heat.

is necessary because it supplies the oxygen used in the process
spiration, and holds the carbonic-acid gas used by the leaves in
ng starch.

ht is essential that a tree may carry on its processes of digestion.
nsitive is a tree to light that it will change its form and habit of
th to obtain the quantity it needs. In a thickly planted group
rees on the edge will bend outward, while those in the interior
row tall and slender, the growth of each hastening in the direc-
f greatest light. In the absence of light a tree ceases the proc-
of digestion by which its food is prepared for use, and in a
time even loses the organs concerned in its preparation; that is,
lorophyl bodies which give the green color to the leaves.

e necessity of moisture is a matter of common observation.
r is one of the chief agents in the nutrition of a tree, as already
ioned, entering into its food in large quantities and serving as a

carrier of food materials from the roots to the leaves. With
inution of its water supply a tree lessens its growth and shed
all of its leaves in its endeavor to survive. If the supply
to decrease it finally withers and dies. Yet in their demands
trees differ vastly. Some can thrive only with their roots
stantly saturated soil—as, for example, the Tamarack of the
and the Bald Cypress of the Southern States. There is every
of variation between trees of this character and those of th
where the annual rainfall is limited to a few inches.

Every tree is adapted to a certain range of temperature, de
upon its power to endure heat and cold. Some, like the pa
thrive only with a constantly high temperature; others, like
the oaks, are adapted to alternating seasons of heat and c
others, as some of the birches and poplars, can endure extr
continued cold, with only a short period each year warm eno
growth. Such adaptations account for the distribution of
over nearly the whole of the earth's surface not constantly co
ice, and also largely for the character of the forest in different
Temperature and moisture principally determine forest dist
and growth.

**Local Influences.**—Local variations in heat, light, and moisture
affect tree growth. It is not uncommon to find very different
on the north side of a mountain from that on the south side,
the north side is cooler, moister, and not so light as the sou
Consequently trees well adapted to the conditions on the no
will flourish there, while on the south side they will make
growth or not appear at all. West of the Mississippi River th
clings to the margins of streams far beyond the point where it
the upland, principally because the moisture and atmospheri
tions along the streams are more favorable to growth.

**Tree Companionship.**—In almost every region certain kinds
are found together. This is due to a similarity of prefer
regard to soil, heat, moisture, and light. Two trees adapted
same conditions will thrive best in the same situation. Th
Ash and Black Walnut are good examples. Having similar
ences, they have almost identical ranges and are very generally
ated. There is also another reason why trees accompany one
A tree may so influence its surroundings as to make them fa
to another tree, where otherwise they would be unfavorable.
example of such influence, the Chestnut on sterile, sandy p
portions of New England forms a much-branched tree, which
the ground and keeps it moist and cool. Such conditions are
ble to the germination of the White Pine in that region; conse
it is found coming up abundantly beneath the Chestnut, but
abundantly on the open, unprotected ground.

**ect of Change in Surroundings.**—A change in the surroundings of
always modifies its habit of growth. If the change is toward
favorable surroundings the result is seen in increased vigor,
of growth, and size; if toward unfavorable surroundings, the
se will be true. The stately Tulip-tree of the central Eastern
s is said to be a mere shrub in Florida. The reason is that there
out of its range of adaptation. The White Elm, which grows
tall and vase-like form in New England, in the semiarid parts of
as and Oklahoma is low and spreading like an apple tree. Nor
m the only variable character. On the western elm the leaves
wer in number, smaller, thicker, and much rougher than on the
England tree. In other parts of the tree there are differences of
me kind, though they are not so noticeable as those in the form
foliage. These variations have resulted from the differences in
nd climatic conditions to which the tree has been subjected.

**adual Change.**—The difference in form between two trees of the
kind in different localities has come about through gradual
rgence of characteristics. To a certain degree changes of this
can be brought about in practice. When a gradual change is
in the surroundings of a tree a corresponding change takes
in the tree itself. Thus if stock of the New England elm be
ly moved westward through many generations, it will gradually
ge in form and other characteristics to be like the western tree;
it must be assumed that this change is necessary to enable it to
under its new conditions.

**dden Changes.**—Sudden changes in the surroundings of a tree fre-
tly cause its death, because it can not quickly change itself to
the requirements of its new conditions. The New England elm
ed at once to the semiarid West is likely to die, because it is not
ted to the conditions of soil, light, heat, and moisture of that
on. In the prairie marshes of northern Indiana there are occa-
l knolls which once supported thrifty oaks of moisture-loving
s. Now that the marshes have been drained the drying out of
soil has caused the oaks to die. The change was too sudden.
enness and intensity of change often account for the failure of
to thrive when moved away from the region to which they were
ted. This is also why Eastern trees so often die when moved to
West. This is why nursery stock grown near by can be more
y planted than that grown in a distant region. It is a practical
er, and should be generally understood.

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## FARMERS' BULLETIN 137.

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# HE ANGORA GOAT.

BY

GEORGE FAYETTE THOMPSON.

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REVISED (MAY, 1908) BY

EDWARD L. SHAW,

*Assistant in Animal Husbandry in Charge of Sheep and Goat Investigations, Bureau of Animal Industry.*

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since died. The present revision has been prepar assistant in animal husbandry in charge of sheep a the supervision of Mr. George M. Rommel, Animal It is based upon the revised edition (1906) of Bull "Information Concerning the Angora Goat," sup from Mr. Shaw's experience and from a recent industry in the field.

The Angora goat industry is now on a firm ba under proper conditions. The interest in the st information continue, so I recommend the public revised article.

Respectfully,

Hon. James Wilson,
*Secretary of Agriculture.*

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# THE ANGORA GOAT.

## INTRODUCTORY.

is probable that as a conservative estimate there are about 0,000 Angora goats in the United States at the present time. estimate is based upon the quantity of mohair purchased by leading mills, making some allowance for the amount of hair by other firms for which no figures could be obtained.

he Bureau of Animal Industry sent out blanks in the fall of for the purpose of securing information regarding the condi- of the industry. Most breeders reported increased sales over ious years and that they had been very successful with their s.

rices of domestic mohair have been steadily increasing in the few years, due to the improvement in the quality of the clip the increased consumption and use of this material.

he increased number of mutton goats sold in the leading markets the prices received for the same during the past year have offered h encouragement to the industry.

he many misleading statements which were formerly made in press regarding the Angora, and which did the industry a great of harm, have almost ceased, and the industry is being regarded its merits and deserves consideration from those who are think- of giving the Angora a trial.

## ORIGIN AND HISTORY.

he Angora breed of goats originated in the vilayet of Angora, sia Minor. The city of Angora, or Enguri, the capital city of vilayet of Angora, is the ancient Ancyra, and is located about 220 s south by southeast from Constantinople. The province is ntainous to a considerable extent and furrowed by deep valleys.

was here that this famous goat reached its perfection. That altitude, the soil, or the climate, or all of them together had h influence in producing this fleece-bearing goat is supported by ng evidence. Dr. John Bachman and the Encyclopedia Britan- both state that the fineness of the hair of the Angora goat may aps be ascribed to some peculiarity in the atmosphere, " for it is remarkable that the cats, dogs, sheep, and other animals of the country are to a certain extent affected in the same way as the goats."

Although this atmospheric effect on the quality of hair is generally accepted, the feed of the animals also has a telling influence, and the experience of Angora breeders show that with good feed and with animals whose blood is adulterated as little as possible with native blood a fleece equal to any produced in Turkey may be obtained.

Mr. Henry O. Binns, who had about twenty years' experience with these goats in the vilayet of Angora, says the pure animals were about bred out in 1863. The reason for this was the extensive crossing with the common Kurd goat, to which reference will be made.

## INTRODUCTION INTO THE UNITED STATES.

During the administration of President Polk the Sultan of Turkey requested of him to recommend some one who would experiment in cotton culture in Turkey. Accordingly, Dr. James B. Davis, of Columbia, S. C., was recommended and received the appointment. The work which he did was so highly gratifying to the Sultan that upon the return of Doctor Davis in 1849 he reciprocated the courtesy of the President by presenting the doctor with nine Angora goats.

The Davis importation of Angoras was frequently exhibited at fairs, and everywhere attracted much attention and received favorable comments.

In 1853 the Davis goats were purchased by Col. Richard Peters, of Atlanta, Ga., with the exception of one owned by Col. Wade Hampton, of South Carolina, one by Mr. Davenport, of Virginia, and one by Mr. Osborn, of New York. Later Colonel Peters imported others, but they did not prove satisfactory. He is generally looked upon as the real founder of the Angora goat industry in the United States.

The Country Gentleman for January 29, 1860, refers to a "recent" importation of 8 Angoras by Hon. William Henry Stiles, of Cartersville, Ga.; the exact date of their arrival is not fixed. Col. J. Washington Watts says of them that they came "just before the war." He stated that they were "larger and stouter than the Davis goats, but inferior in fleece."

The following statement by Winthrop W. Chenery, of Belmont, near Boston, on the two importations of goats which he made, was published in the Massachusetts Ploughman in 1862:

> Two importations of these beautiful animals, purchased in Constantinople and consigned to planters in the South, have been landed upon the inhospitable shores of Massachusetts. The importations of the Angora, or Cashmere, goats, to which we refer, are at the Highland stock farm of Winthrop W. Chenery, of Belmont, near Boston.

he first of the two lots, consisting of 29 animals, was shipped at Constanti- le on the 26th of March, 1861, and arrived at Boston on the 15th of May. second lot, consisting of 41 head, left Constantinople on the 6th of October, 1, and arrived here on the 25th of November.

Mr. Landrum states that further shipments of goats were made by . Chenery, one of 20 head in 1866, another of 20 head in 1867, d that only about 30 of the 40 head arrived alive.

The Diehl and Brown importation of 160 Angoras was probably de during the year 1867. The Country Gentleman for December 1867, says:

> ne hundred and sixty of these goats purchased by Israel S. Diehl recently ved in this country and have been placed on the farm of C. S. Brown, of ark, N. J.

Previous to the outbreak of the civil war there were many fair- d flocks of Angoras in the South and Southwest, and there were ller flocks in many of the Northern and Western States.

On account of the civil war little or no progress was made in the th, where the largest herds were located and where the most in- est was manifested, until about 1866. Soon after the close of the r they spread out into the West, principally into Texas and Cali- nia, where the natural conditions were most favorable and where y have increased in large numbers.

## LATER IMPORTATIONS.

Mr. John S. Harris imported 2 bucks and 10 does, which arrived Baltimore March 23, 1876, having cost $525 each landed in that ty. An importation for which no positive date is fixed was made by . W. Jenks, of Boston, and sold to Colonel Peters, and is noted in Boston daily paper of January 31, 1880, which states that the eamer *Dorian*, from Constantinople, had arrived, having on board goats for C. W. Jenks, of Boston.

On August 13, 1886, 2 bucks and 2 does arrived at New York rom Delagoa Bay, consigned to E. A. Shults, for Fink & Co., of eon Springs, Tex.

In 1893 C. P. Bailey imported 2 bucks from South Africa, and 1899 another buck from Cape Town.

Previous to 1901 the last Angora goats that had been imported to the United States from Asia Minor were those imported by ohn S. Harris in 1876; and previous to 1901 he and Israel S. Diehl ere the only importers who went into the vilayet of Angora for heir goats. During the early part of 1901 Dr. W. C. Bailey, of the rm of C. P. Bailey & Sons, California, visited Asia Minor and was ccessful in securing 4 animals, and after many difficulties they were nded in New York and then shipped to California.

William M. Landrum, of Texas, who was the first to introduce Angora goats into California, succeeded in importing 2 yearling bucks from South Africa in 1901.

Mr. G. A. Hoerle, of New Jersey, visited South Africa in the interest of the Angora goat industry, and on May 29, 1904, landed at New York with 147 head of Angoras from Cape Colony.

E. L. Witt & Sons, of Texas, purchased a 4-year-old buck from O. Cawood, of Cape Colony, South Africa, in 1905. This buck, "White," took first prize at the Port Elizabeth show in 1904.

In 1901 South Africa passed a law, which is usually referred to as "the Angora export duty act, 1901." This act provides for an export duty of £100 ($486.65) on each Angora goat and each ostrich, and was to go into operation when the several governments of South Africa should agree upon a date. On September 20, 1904, Mozambique issued a decree ratifying the export duty. This was followed by a proclamation by the governor of Natal on December 13, 1904, providing that the law should go into effect January 1, 1905.

## DESCRIPTION OF THE ANGORA GOAT.

Mr. Israel S. Diehl, bearing a commission from the Commissioner of Agriculture, visited the province of Angora in 1867 to investigate the mohair industry. Here, where there were once in operation 1,700 to 1,800 looms working up the mohair fleeces, he found but a few hundred remaining, struggling hopelessly against the fatal competition of European machinery and the aggressive policy of the European governments. The fleeces were exported to Europe for fabrication, thus rendering Turkey tributary to the monopoly then existing in this industry in Europe. The European demand for the raw material was so great and the facilities to fabricate it so much better and cheaper that Turkey was compelled to export the raw mohair. In order to meet the demands for manufactured mohair, the Turkish growers, without wise foresight, began the practice of crossing the Angora upon the common Kurd goat of that country.

These conditions have produced various types of Angoras, even in Asia Minor, and a minute description of one would not apply to all. Some strains have foxlike ears, while others and generally preferred ones have long pendent ears. In this country care must always be exercised to cull the off-colored kids out of the flock. These may be the result of atavism, where a cross was made upon a common goat, either red or black; but it is reported by some that different colors are found in the province of Angora among what were supposed to be purebred animals.

Mr. Schreiner, in his work previously mentioned, has compiled the descriptions of almost all writers on Angora goats. He quotes Mr.

nry O. Binns, who spent twenty years in the mohair districts of a Minor between 1864 and 1886, and who studied them during that e, as follows:

> he pure Angora in his prime is about the size of a five-months-old Cape pe of Good Hope] kid, with small thin horns, wooled all over the body, their r almost covering the eyes; exceedingly delicate, and so subject to disease t no one cared to keep him. What is to-day called the purebred Angora is the English thoroughbred horse—the result of crossing and recrossing until y, class, points, etc., have attained to what is generally considered that the roughbred Angora ought to be.

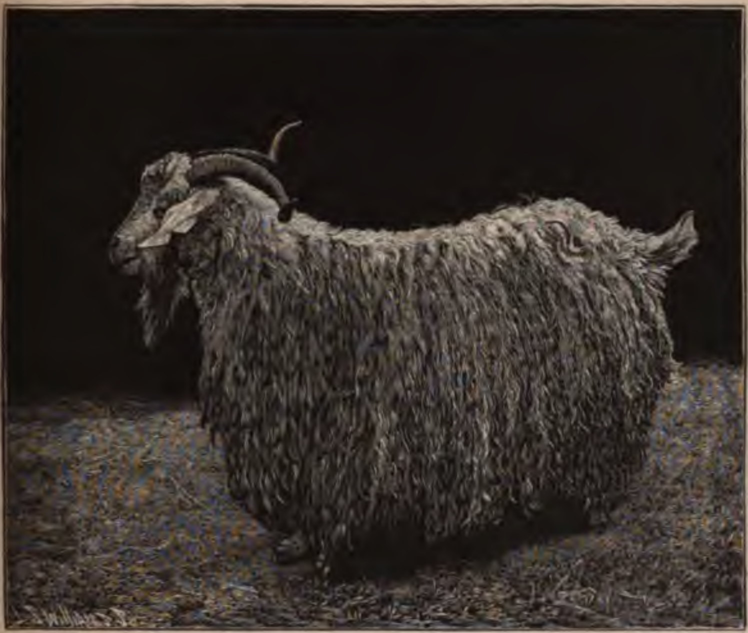

FIG. 1.—Angora buck "Prosperity," showing mohair 19 inches long.

The opinion of Mr. Schreiner, the South African authority, of a urebred Angora is as follows:

> I think it is certain that the original purebred white mohair goat was a small, ery refined, delicate animal, of great beauty, clipping at twelve months' growth f fleece about from 2 to 4 pounds (according to age and sex—kids considerably ss) of dazzling white, fine, soft, silky, very lustrous mohair, curling in ringlets rom 10 to 18 inches long, with merely the minimum of oil in its fleece requisite the growth of hair of the highest excellence, so small in amount as to be appreciable to the unskilled observer. It was perfectly clothed in every part; had short, silky, curly hair about the face and down the lower parts of the gs to the hoofs; a soft, silky, curly "kuif" (tuft on the forehead), and small, hin, light-colored horns. The ewe was of course smaller and finer than the ram, nd had only one kid at a birth (of this there is abundant evidence).

Mr. Diehl mentions a variety of this goat in Angora which was hornless. There is reason to believe that an intelligent system of breeding would produce such result.

A few years ago, before much effort had been made to improve the Angora goat, it was described as a little animal; but under favorable conditions its size has been greatly improved, although it is yet considerably smaller than the average sheep. The future may cause a change of opinion as to the weight that is desirable, but at this time it is believed that the aim should be to produce animals weighing at maturity from 60 to 100 pounds.

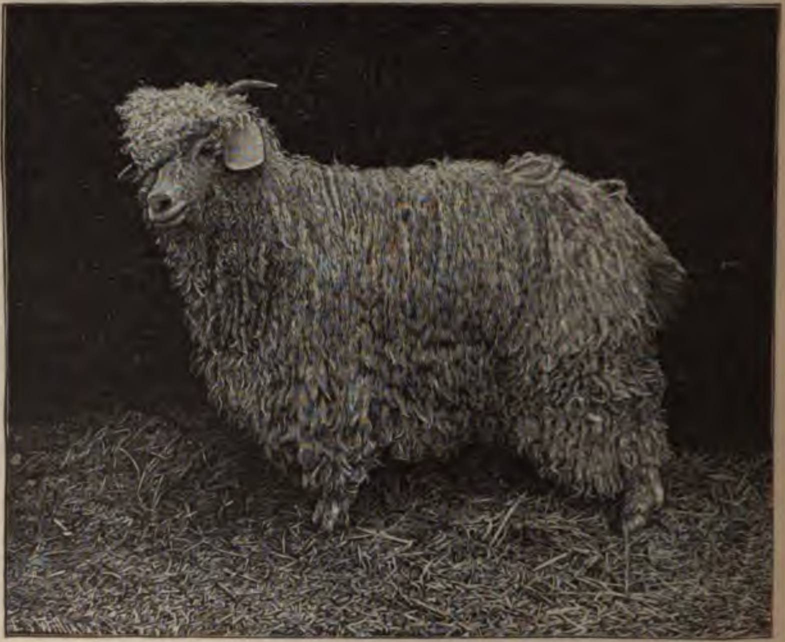

FIG. 2.—Angora doe "Princess Monterey," 10 months old. Fleece 4½ pounds.

Males and females alike have horns and beards, except that in rare instances an animal without horns may be seen. The horns of the male grow to a length of 18 to 20 inches and turn upward, outward, with a backward twist, while those of the female, which grow to a length of 8 to 10 inches, grow upward and point backward with only a slight inclination to twist.

The body should be round and broad throughout its length; hips and shoulders of equal height, as low shoulders indicate a delicate constitution; hips not sloping in a pronounced degree; chest broad; legs short. The head should be broad, with a wide muzzle and bright eyes; ears may be partially upright or distinctly pendent.

The fleece should cover all parts of the body except the inside of the upper part of the legs. While some animals show mohair down the legs to the feet, this does not indicate a better individual than may be found among those that have no mohair below the knees and hocks. It does indicate, however, a strain producing a heavier fleece. The fleece should make an annual growth of not less than 8 to 10 inches and be so dense upon the animal as to yield from 4 to 6 pounds. The ringlets should be well formed from point to skin, and the tighter these ringlets are twisted the better; loose, slightly wavy hair is objectionable and indicates coarseness and brittleness, and often lacks luster. It is of the utmost importance that the hair be extremely fine—the finer the more valuable. The ideal Angora should be free from kemp. No other thing tends so surely to reduce the value of the fleece as the presence of kemp; and the more kemp there is present the less valuable the fleece, no matter how fine the mohair may be.

A characteristic of the common goat that is very objectionable is the ever-present offensive odor from the bucks; in the Angora breed this odor is entirely absent, except at the rutting season, and then it is noted in a slight degree only. The odor in a fleece of mohair is milder than that in a wool fleece, and is not at all offensive.

## NAMES OF THE SEXES.

Previous to the appearance of Bulletin 27 of the Bureau of Animal Industry, entitled "Information concerning the Angora Goat," there were no well-established names for designating the sexes of the goats. The male was indiscriminately called "male," "sire," "buck," "ram," and "billy," and the female "doe," "ewe," and "nanny." Often a writer uses two or more of them in one article, showing that he had not adopted any of them. An investigation developed the fact that the terms "buck" and "doe" were preferable, and these, being used in the bulletin mentioned, have generally been adopted by breeders everywhere. The castrated animal is called "wether," as with sheep. The young is called the "kid."

## USES OF ANGORA GOATS.

A large number of people in some way have become possessed of that opinion that the goat is practically a useless animal. Not only do investigations prove that the Angora goats are classed among the most useful of the domestic animals, and have been so classed for thousands of years, but their usefulness is manifested in a variety of ways. The fleece, called "mohair," furnishes some of the finest of fabrics among ladies' goods and is used extensively in the manufacture of plushes and in various other manufactures which will be mentioned later on; their habit of browsing enables the farmer in a wooded locality to use them in clearing the land; their flesh is exceedingly delicate and nutritious; the milk, though not so abundant as with the milch breeds of goats, is richer than cow's milk; their tanned skins, though inferior in quality to the skins of the common goat, are used for leather; their pelts make the neatest of rugs and robes; they are excellent pets; a few of them in a flock of sheep are a protection from dogs; their manure is noticeably helpful to the grass which follows them after they have cleared away the underbrush. These are all subjects of varying degrees of importance, and most of them will be considered under appropriate heads.

## BROWSING AND PASTURAGE.

### CLEARING BRUSH LAND.

Goats are browsers by nature, and there is no vegetation they will eat in preference to leaves and twigs of bushes. While this fact would at once establish them as an intolerable nuisance in an orchard or garden or any other place where desirable shrubbery is growing,

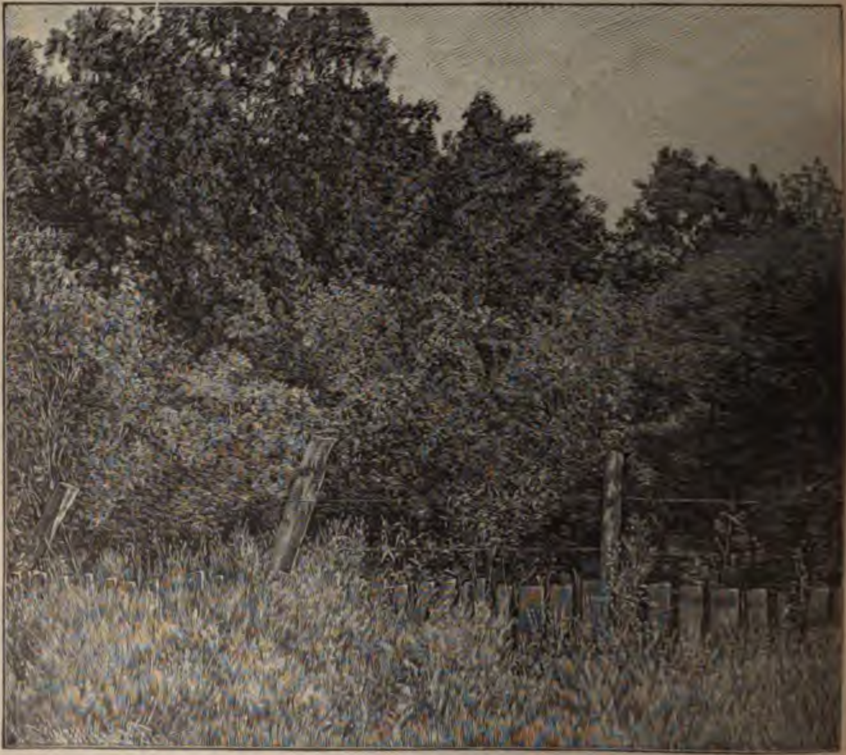

FIG. 3.—Brush land "before goating."

it also shows that they may be of great value in many localities where it is desirable that underbrush be destroyed. Every leaf and every twig within their reach is greedily eaten, even to most of the bushes and weeds that are considered poisonous to other ruminants, while a remarkably few weeds are passed by.

The inherent tendency to climb leads them to hillsides and rocky cliffs, and they prefer such situations to any of a level character. Here nature meets their necessities by dwarfing the bushes so that they may be browsed easily; the soil is quickly drained in the event of rain, for they do not like wet land, and the stones serve to keep the feet trimmed properly by the wearing process. This is the situation that the goats would choose, but the farmer might choose to turn them into a dense mass of brush and weeds anywhere and they will at once begin to convert it into the most beautiful pasture.

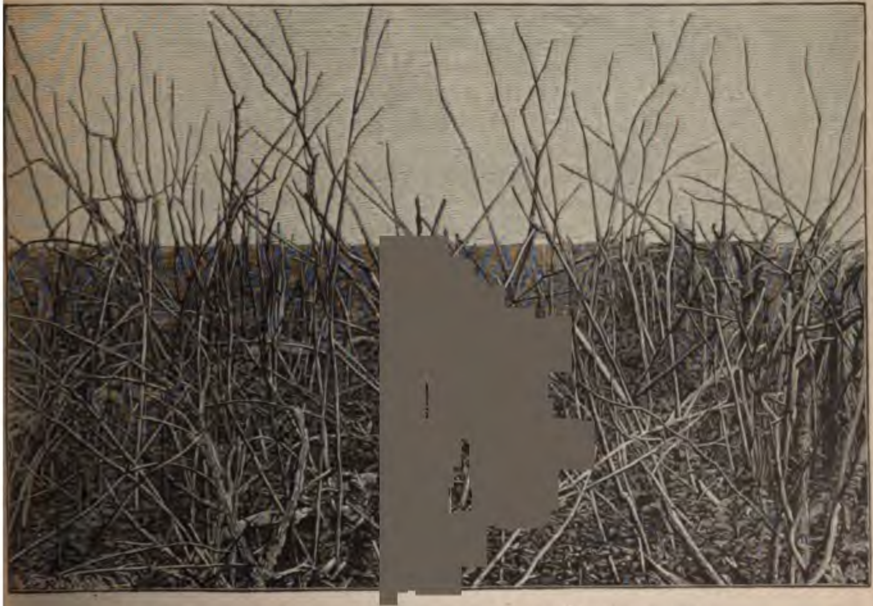

FIG. 4.—Brush land "during goating," after twelve months.

In their efforts to get at the leaves and twigs the goats will stand on their hind legs and strip the saplings to a height of 5 or 6 feet.

Why the value of goats as brushwood destroyers was not recognized years ago it is difficult to say. Dr. J. R. Standley, of Iowa, is supposed to be the discoverer of this economic use of goats. An article in a consular report on the propensity of milch goats for destroying brush and scrub attracted his attention, and he at once saw that the characteristic which made the goat a nuisance abroad could be put to beneficial use upon his own tract of land, which was useless on account of its dense growth of underbrush. Doctor Standley at once secured a carload of Angoras and turned them upon his land with the most gratifying results. His opinion of goats as brushwood destroyers is given herewith:

> Land can be cleared of the worst brush known to this country for a little less than nothing by Angora goats. Some one asks how. Simply this: Angora goats will pay a profit and live on leaves and weeds, leaving the land cleaner and nicer than can be done in any other way. Many persons have the idea that goats bark the trees and in that way kill them. They also think that goats wholly eat the hazel and other small brush. There is nothing in this. Goats are no worse to bark trees of any kind than sheep. The way in which goats kill brush is by continually cropping the leaves, which serve as the lungs of the brush. The continued cropping of the leaves makes the brush, as it were, sick, caused by lack of nourishment. This sickness sinks to the very extremity of the roots, thus preventing sprouting. Any and all kinds of brush are in this way easily killed. Some kinds of brush and some kinds of stumps are of course much harder to kill than others. Many varieties are entirely killed by one summer's trimming of the leaves. Almost any are killed by two years' trimming. To clear the worst brush do not cut anything that the goats can reach or bend. The tallest or largest is better not cut. All trees and saplings should be cut, and the goats will keep all the sprouts down. If stumps are allowed to sprout one year before the goats are turned in, the sprouts need not be cut. About 200 goats for 40 acres of brush will in two or three years make the land as clean as a garden. If the pasture has only patches of brush, turn in a few goats and it will make more grass for other stock than if the goats were not in. They eat very little grass when they can get leaves. Goats even like weeds better than grass. In clearing brush land in the old way by grub and plow there are always left many eyesores in the way of brushy nooks and bends and steep places which can not be plowed.
>
> There are millions of acres of land in nearly every State in the Union which might be much more than doubled in value by the use of Angora goats at no cost at all. Commence and count the worth of your land, then the fencing, and see if you can afford to leave your brush land so nearly worthless for all time. Then count the cost of grubbing and plowing, if indeed such land is susceptible to the plow. No man can afford to grub and plow brush land in this day and age of the world any more than he can afford to plant a large field of corn without a planter. In hilly or mountainous portions of the country the Angora goat can be made to do a great service in the way of clearing the underbrush, when the land will bring grass after the brush is gone. It would surely be a paying business to buy up large tracts of rough land in the mountain districts, or indeed any brush land in the United States, and clear the brush and set in grass. Afterwards, if the owner liked other stock better, he might dispense with the Angoras. In many places where the country is too bare to furnish sheep with sufficient feed goats will do exceedingly well. In many places where leaves are abundant and there is scarcely any grass, making it impossible to profitably keep sheep, goats will do admirably well.

Upon the recommendation of Doctor Standley, based upon his experience, thousands of goats were taken into Iowa for clearing brush land some time before they were seriously considered elsewhere.

Doctor Standley's experience is but that of many others, and testimonies of the goat's ability as a brushwood destroyer have come from ts of the country. There is no doubt that the question of ood is a serious one in many sections of the United States, eing millions of acres of land covered with brush, ferns, and thus being practically useless for pasturing. There seems to nore economical way for clearing up this land than by the use goat.

ocalities where valuable land is completely overgrown by ood the goats are considered of more value for the purpose ring it than for their mohair and meat. Their value in this must be measured by the value of the land which they render ble.

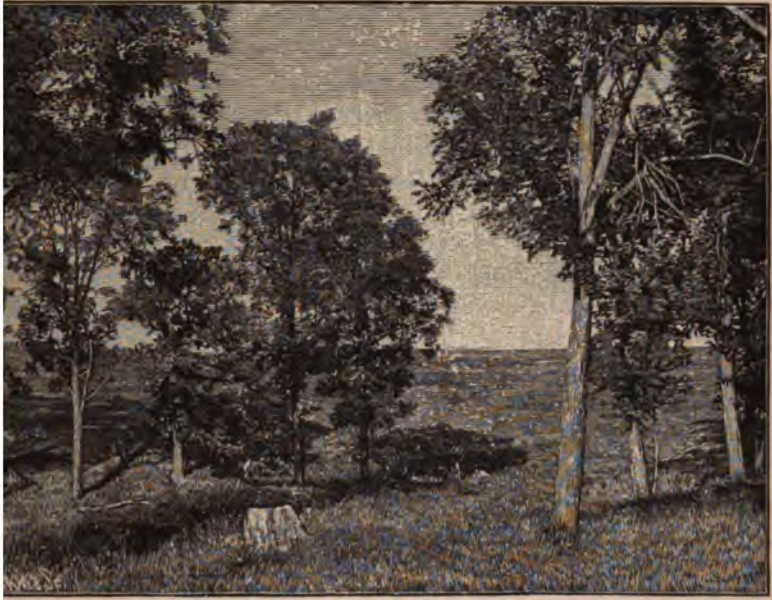

FIG. 5.—Brush land "after goating" two years.

e saplings are too large for the goats to manage, they may be wn, so that the animals may get at the leaves and twigs at the

rush must be subdued continuously for two or three years to roots, it is necessary to keep the goats on it for more than one . Most shrubs will start anew from the roots, and if the land e converted into pasture or cultivated the goats should have n of the wood lot for at least a part of the time for two or years. In this time a large amount of the richest kind of e will have been deposited on the land, which aids the grass in wth.

ost every kind of vegetation is relished by goats. They are not f hickory, alder, and pine, but have been known to eat them greedily at times. In Maryland and Virginia there is a great deal of broom sedge, which will not be touched by other live stock, but goats consider it a favorite feed.

The fact must not be overlooked that the brush-destroying habit is common to all kinds of goats. The common goats will do the work as well as the Angoras. The latter are employed for the purpose because they are more plentiful and because there is profit in their progeny for breeding purposes, their mohair, and their meat.

## OTHER ADVANTAGES OF BROWSING.

The browsing habit of goats is important in connection with the question of feeding. In some places they obtain enough browse to carry them through the winter. This is especially true in the Southwest, where there is so great an abundance of live oak. If snow is on the ground, or if for other reasons the goats are deprived of opportunities for foraging, the trees are cut down for them. They pass through the winter in good condition without other feed. Wherever they are deprived of opportunities for browsing, they must be fed. Browsing saves feed. As far north as Nevada goats subsist the winter through on sagebrush.

Some persons claim that the animals make a better growth among the bushes than on open pastures, and that the quality of the fleece is much better.

Many correspondents state that it is the browsing of the Angora that gives to the meat the game flavor, thus leading some to name the meat "Angora venison." It is also stated that when deprived of browse and fed on grass and grain the game flavor disappears.

## PRESERVING BRUSH LAND FOR BROWSING.

Up to this point consideration has been given to these goats as a means of clearing land for pasture or for cultivation. There is much brush land in the United States which will support goats, but is good for nothing else. If this is to be devoted to goat raising, it is, of course, not desirable that the brush be entirely exterminated. In this event a goat raiser should have several fenced areas and change the goats from one to the other frequently. They should not be permitted to denude entirely one field before they are transferred to another. It is true, however, that no matter how perfectly a woodland may be cleared of brush it will be covered over again with briers and brush in a few years if constant attention is not given it. It is not difficult to overpasture such land, and if the goats adopt the "peeling" practice the brush and trees will have greater difficulty in recovering.

## OBJECTIONS TO SOME BRUSHWOOD.

The statement has been reiterated over and over by the newspapers, in mentioning the spread of the Angora goat industry, that these goats will eat all kinds of poisonous plants without any harmful results. While there is much evidence pointing to this conclusion, it ought not to be taken as a settled fact. If experiments were undertaken it might be shown that a plant which is poisonous to sheep or cattle is also injurious to goats. It is observed that goats feed upon brushwood by snipping off a leaf here and there—from a pine here and a cedar there, a grass blade here and a weed top there, and so on; they do not, like the sheep or cow, eat a weed entirely or strip a bush clean before passing on. The result is that the goat's stomach is filled with a great variety of food and not much of any one kind. If by chance a few poisonous leaves are eaten, they are probably neutralized by the large quantity of other food eaten.

Upon a farm in Pennsylvania there was a patch of laurel where goats had passed it by during the whole season. This was evidence that they knew it was not good for them. Later in the season several hundred goats were turned into that same pasture after a long journey and when they were very hungry. The laurel patch was the only green food in sight and they ate of it greedily. The next morning found 300 of them very sick and 50 dead. What had proved harmless to the goats that had been there when there was an abundance of other feed proved exceedingly poisonous to the hungry newcomers.

While it is possible that goats may not eat laurel to such an extent as to be injurious if placed in a pasture where it is growing with other browse, it can not be considered a safe practice. The laurel best known is the narrow-leaf variety (*Kalmia angustifolia*). According to V. K. Chesnut [a] this species "is abundant in the northeastern section of the United States, where it is also known as sheep laurel and lambkill. The leaves contain andromedotoxin, and sheep and calves are quite frequently poisoned by eating them."

The greenbrier, which appears to have a wide distribution in the United States, is an enemy to goat raising; not that it is poisonous, but because of its physical character. It is a climbing shrub, very wiry, and well covered with very hard and tenacious thorns. They grow in clumps and to great length, and preferably on lowland near creeks or ponds. It is a very easy matter for these thorns to catch in the fleece and hold the animal fast until it dies. No goat has strength sufficient to break the shrub, and the thorns do not give way. These shrubs should be cut down with a brush scythe and burned before goats are permitted to go among them. Where goats have had access to greenbriers immediately after shearing, when there is no fleece to catch upon the thorns, they have destroyed the briers by eating the leaves and by girdling.

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[a] Fifteenth Annual Report, Bureau of Animal Industry, 1898, p. 141.

It must be understood that goats can not do very much toward destroying trees after they have reached the sapling stage of growth.

## GOATS AS GRAZERS.

While it is true that goats are browsers by nature, they will subsist nicely on grass. Several successful breeders believe that goats fed on grass will produce a finer and heavier fleece of mohair, with less wax and gum, and that it will have more luster than if the animal feeds on browsé.

Considerable interest has been manifested in the Angora industry in those localities where browse is not available and where grass and weeds form the only pasturage. A great many inquiries of this character have come to the Bureau, and the Bureau, in turn, has referred the matter to the breeders of the country. The replies received have been numerous, and show a difference of opinion. The predominant opinion, however, seems to be that the goats thrive best under the conditions most nearly like those of their original home. It is certainly the best argument to say that goats prefer any kind of browse to the most nutritious of grasses, which is true, and therefore browse is better for them than grass. While the more economical conditions obtain where there is an abundance of browse, it is not definitely settled that the goats will not thrive well on common pasture grasses. It is the opinion of the writer that this question is still an open one, as some successful breeders have had goats on the grass range for thirty years.

There is always expense in connection with pasture grasses, but there is little or none with browse. One of the chief reasons why goats are receiving so much consideration at this time is that they are practically inexpensive feeders, and so all items of expense must be figured on if profit is to result. Pasturage, unlike browse, is not available all the year through. Therefore in prairie locations feeding in winter is a necessity.

## PASTURING WITH OTHER STOCK.

So far as the goats themselves are concerned, they may be kept in the pastures where there are sheep, cattle, and horses. Their presence is in no way obnoxious to any of these animals. A few of them in a flock of sheep are a protection against dogs. However, it is not best for the goats that they be kept in pastures with horses. This is specially important if there are kids, as the horses have a habit of layfully chasing any animal that is not large enough to defend itself, nd they are apt to strike the kids.

### NUMBER OF GOATS TO AN ACRE.

Questions are frequently asked with reference to the number of oats to an acre. The number will depend, first, upon the object in asturing on brush land, whether it is to kill the brush or to use it as permanent pasture for the goats; and, second, upon the quantity f feed obtainable.

## MOHAIR.

### DESCRIPTION.

The word "mohair" is the technical and commercial name for the leece of the Angora goat, which is used in the manufacture of fabrics. The word comes to us, through the old French "mohere," from the Arabic "mukhayyar," meaning goat's-hair cloth.

The fleece upon the goat is pure white, is exceedingly lustrous, and grows to an average length of 10 inches annually. It hangs in beautiful wavy curls, or ringlets, from all parts of the body, if the animal is of the best breeding. The average annual production of mohair is about 4 pounds a head. The grade of the goat has much to do with the weight of the fleece. The first cross of an Angora buck upon a common doe gives but a small amount of mohair, but the increase in quantity is noticeable as the crosses become higher.

Mr. C. P. Bailey states as follows:

> Half-breed goats scarcely shear enough to pay for the shearing; three-fourths-bred goats shear 1 to 1½ pounds, worth 15 to 20 cents; seven-eighths-bred goats shear 2 to 3 pounds, worth 20 to 30 cents; fifteen-sixteenths-bred goats shear 3 to 5 pounds, worth 30 to 40 cents.

All mohair has a luster peculiarly its own, but this is much more pronounced in some fleeces than in others. That having the higher luster, other qualities being equal, commands the better price. A fleece of low luster indicates a goat under influence of adverse conditions—as poor breeding, poor feeding, or sickness. The uninformed often express the opinion that this luster is due to oil in the fleece, but this is erroneous. Whatever oil there may be in mohair is inside the individual hairs, and not on the outside, as in the case of wool. A mohair fleece may be washed, then scoured, and then steamed, dyed, and worked up into fabrics after reaching the mills, but none of these processes removes any of the luster; indeed, all of them operate simply to intensify it.

The properties of this fiber which render it desirable are lengt fineness, luster, strength, elasticity, and specific gravity, and the are relatively desirable in about the order given. There is no diffi culty in securing length and strength, but the other properties mus come by the most painstaking care by breeding. Having length strength, and luster, the manufacturer wants the fiber as fine as ca be bred. The length of the clip is the quality that gives to mohair it relative value. The manufacturers desire a long fiber, very fine, an strong. While there are uses for coarse grades of good length, th price is not so good as for the finer grades. The latter are used prin cipally in the manufacture of plushes and the coarser grades in dres goods, coat linings, etc. The colder climates increase the fineness and add to the weight.

The following table, which is compiled from a "Report of exami nation of wools," etc., by Dr. William McMurtrie, and published by the Department of Agriculture in 1886, gives a very interesting com parison between length, fineness, strain, and stretch of mohair and commercial grades of wool:

*A comparison of mohair and wool fibers.*

| Description. | Length. | Fineness. | | Strain. | | Stretch. | |
|---|---|---|---|---|---|---|---|
| | *Inches.* | *Centimillimeters.* | *Thousandths of inch.* | *Grams.* | *Grains.* | *Millimeters.* | *Per c* |
| Mohair (average of 480 tests).. | 6.91 | 3.157 | 1.2429 | 19.12 | 295.11 | 10.60 | [illegible] |
| Commercial wools (average of 1,410 tests)................. | 2.62 | 2.118 | .8352 | 7.01 | 108.79 | 5.02 | [illegible] |

It will be observed that mohair is not equal to wool in fineness, but in strain there is a difference much greater than would be suggested by the larger fiber. The average wool fiber in these tests stood a strain of 108.79 grains, while the average mohair fiber stood a strain of 295.11 grains. This is a difference of 186.32 grains—much more than double the strength of wool. It is to this strength of fiber that the great durability of mohair goods is ascribed. In stretching quality there is but a slight difference between mohair and wool. Doctor McMurtrie makes the point in discussing wools that the individual fibers may be variable in size, a condition brought about, it is supposed, by sudden changes in weather or feed, or by ill health.

## CONDITIONS INFLUENCING QUALITY.

Feed and care have a great influence upon the weight and fineness of the fleece. If goats are exposed to sudden changes of weather the effect is shown in the fleece.

some parts of the United States where the climate is dry and oil is distinctly alkaline the natural yolk disappears from the ir, leaving it dry, , and harsh.

e fiber becomes er as an animal s older. The best grows upon goats ie best blood, and g these that upon yearling wethers, does, in the order d, is preferred.

e best fiber is usu- very curly, or, r, in ringlets, but kinky. It loses its and becomes thin- , coarser, and ghter as the animal s older.

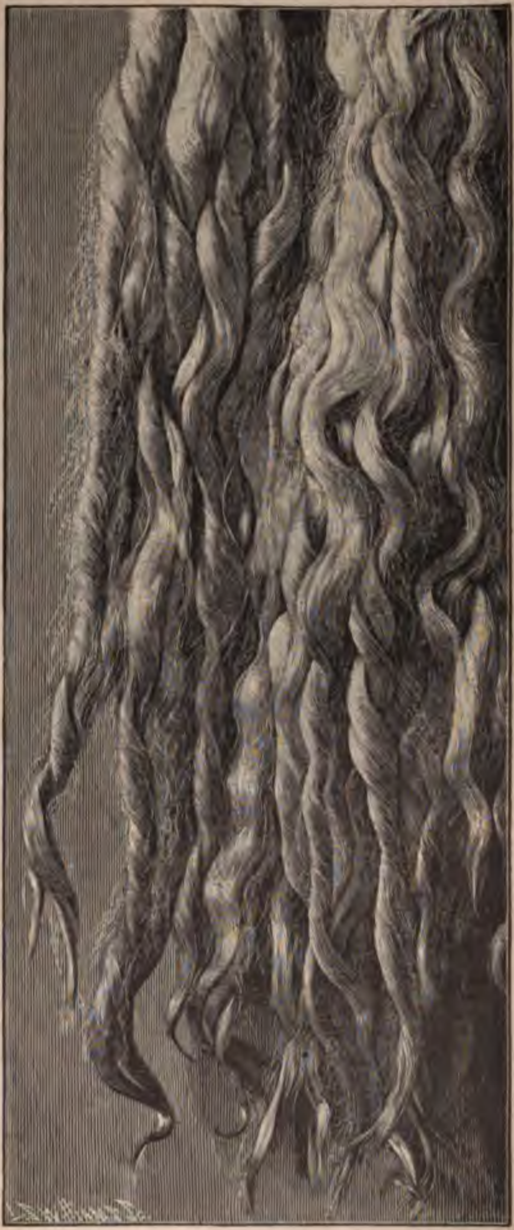

Fig. 6.—Samples of mohair.

### HT AND LENGTH OF FLEECE.

e weight of the is always a sub- of inquiry, and is a ilt question to an- because of the con- ng circumstances— as climate, feed, and above all, the e of Angora blood ie animal. At the nt time the average it of the fleece in nited States is from 5 pounds and the n about 8 inches. are, of course, in- ual goats of high ing that will shear 2 pounds and carry ce 12 to 18 inches long. In the southern part of the country, shearing is done twice a year, the fiber is shorter.

## SHEARING.

In Texas, New Mexico, Arizona, and sometimes in California, shearing is done twice a year—in the months of March or April and in September or October. The reasons are that, owing to the warm climate, the fleece will often shed in the fall if not clipped. There are instances in these localities where goats carry their fleece through the year, but all breeders, except in some parts of California, report the practice of shearing twice a year. In other parts of the country shearing is done but once a year, and that in the months of March or April. The rule for shearing time does not depend so much upon the calendar as upon the condition of the fleece. It should not be delayed until the fiber begins to shed, as then the oil will begin to go back into the body of the animal, the mohair thus losing its life and luster.

As to the relative values of the semiannual and annual fleeces, there does not seem to be much difference of opinion. The semiannual fiber is shorter and therefore less desirable for fabricating, and the price is not so high as for that of the annual fleece. It is generally agreed that the two shearings combined weigh a little more than the annual shearing, but probably the increase does not average more than a quarter of a pound. However, some who have practiced it report that the gain is not equal to the cost of the second shearing, and that shearing twice a year is done from necessity rather than from the standpoint of profit.

It is well to bear in mind that the mohair manufacturers prefer long hair, above 6 inches, and that they have not yet been able to secure all this staple they need.

The use of shearing machines, largely employed among sheep raisers, is coming more and more into general use among goat raisers. The machines are more rapid than hand work, and the results are more satisfactory. The cutting of the skin is easily avoided in reasonably careful hands, while it requires extreme care with hand shears to prevent cutting.

Of course the goat raiser will consider the relative cost of shearing with machines and by hand before he will purchase a machine. The decision will probably depend upon the number of goats. The cost of shearing is about 4 cents a head in the South and from 7 to 10 cents in the North. In the Southwest there are Mexicans who follow the profession of shearing sheep and goats; these usually receive 2 cents a head, with their board. Many of them will shear 85 or 90 a day, the average of all being about 60. Any man who can shear sheep can shear goats. If shearing is done by hand, a short-bladed shear should be used in order to avoid cutting the hair twice. Another objection to hand shearing is that there is often double cutting of the hair. The result is a shortening of the fiber and an increased amount of noilage.

Goats are not so gentle in the hands of the shearer as sheep, and many men, especially beginners in the industry, are anxious to know how best to handle them during the operation of shearing.

The late F. W. Ludlow, of Lake Valley, N. Mex., devised a shearing table which has proved to be of great service. It is a collapsible trough, or combination table and trough.

Mr. Ludlow's description of this table is given herewith:

> The table is simple in construction. It is about 22 inches high, 2 feet 10 inches long, and 21 inches wide. The top is composed of two 9-inch sides, which are hinged to the 3-inch centerpiece. On the lower side of these movable flaps is a narrow piece 8 inches long, which catches on the framework of the table when the sides are lifted and holds them stationary. When the sides are elevated, the top of the table forms a trough 3 inches wide at the bottom and possibly a foot wide at the top. Into this trough the goat to be shorn is thrown feet up. A small strap, which hangs from the end of one of the sides, is run over the goat's neck and fastened to the other side. The goat's head is hanging over the end of the table and the strap prevents it getting free. The belly and legs are then shorn. The legs of the goat are then tied together, the strap removed from the neck, and the sides of the table dropped, so that one has a plane surface on which to shear the rest of the animal. An untrained man can shear 100 goats a day with a shearing machine and such a table.

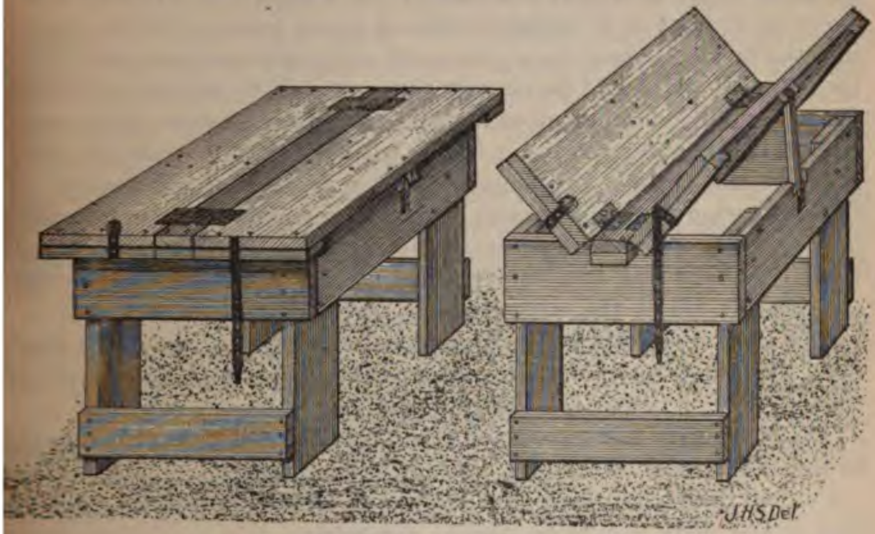

FIG. 7—Combination shearing trough and table.

### SHEDDING.

There are a few breeders who maintain that purebred Angoras would not shed their fleeces under natural conditions; there are others who claim that they would shed biennially; others maintain that the matter of shedding and nonshedding is a question of feed and care, and still others claim that it is perfectly natural for the Angora to drop his fleece annually.

As a rule, Angora goats, like sheep, shed their fleeces annually as soon as the warm spring weather sets in. In the Southern States it is found that they will shed twice a year, and it is for this reason that semiannual shearing is practiced.

## CARE OF FLEECES.

It may not be known to goat breeders generally that the objection to any foreign fibers in mohair is the same as that which holds against kemp, namely, they will not take the mohair dyes. Therefore, if every particle of such foreign substance is not removed before going into the fabric, it shows in a prominent and unpleasant manner when the article is dyed, and necessarily cheapens it if it can not be burled out. For this reason mention is made here of the practice, quite general in this country, of tying fleeces with twine. In removing this twine at the mills it is almost impossible to prevent portions of it from adhering to the fleece, and it must be removed so far as possible by the most painstaking care. Fleeces from Turkey and Cape Colony are not tied, but simply rolled up inside out, and this is the condition in which the mills desire to receive them.

Few goat breeders wash their goats before shearing, and if the animals have been well cared for during the winter and early spring washing is not necessary. The mohair manufacturers will not pay as much for dirty fleeces, and the breeder will find it to his advantage to ship his mohair in as clean a condition as possible.

Colored fleeces, tag locks, mohair that is clotted, and that which is kempy and dirty should be packed separately.

As kid hair is usually the finest, it should be packed by itself; the doe hair and that from the wethers, if the hair is of about the same quality, may be packed together, and should be separated from coarser fleeces. The difference in price obtained for hair that has had this small attempt at sorting will be considerable and well worth the effort.

The operation of shearing should be done in a building free from straw and dirt, which might adhere to the fleece after it drops from the goat. The fleece should then be rolled up inside out and packed in the sack without being tied in any way.

The very short hair, mane, kemp, and the hair that has been cut twice in shearing are, together, called "noils," and this must all be combed out before the mohair can be spun. The noilage in Turkish mohair is only 15 to 20 per cent. In our domestic product it runs as high as 40 per cent. Noils are worth from 20 to 25 cents a pound.

### KEMP IN MOHAIR.

Besides the mohair there grows upon the Angora goat coarse, chalky white, stiff, straight hair, varying in length from half an inch to 4 inches, technically known as "kemp." It is generally believed that kemp is a relic of the common goat blood in the Angora, as it is a matter of history that the Angora flocks of the United States, as well as those of Asia Minor and South Africa, have been largely increased by crossing upon does of common blood. This argument seems plausible for two reasons: First, there is a certainty that there are no Angoras now in existence which are absolutely purebred, on account of crossing with common Kurd goats practiced many years ago by Turkish breeders; second, it is noticeable in building up a flock by crossing upon common goats that the kemp gradually grows less with each succeeding cross. That point has not yet been reached, however, where it can be said that a strain has been produced which has no kemp whatever, although a few breeders in this country and in South Africa appear to have very nearly reached that desirable result. This is the principal end to which breeders should lend their best efforts at this time.

The reason why kemp is objectionable is that it will not take the dyes used for mohair; the only effect of the dyes is slightly to discolor the kemp. There are dyes, it is true, which act upon kemp, but they have no effect upon mohair; and the best efforts put forth have not yet resulted in a mixture of dyes that will act satisfactorily upon both mohair and kemp at the same time.

Kemp appears in its worst phase in plushes, where every individual hair shows prominently. Its presence here is much more pronounced than when in the fleece, where it is nearly of the same color as the mohair. It is therefore of great importance that this objectionable substance should be removed from the fleeces. If any kemp should escape the eye and be woven into the plush fabric it would not be discovered until the fabric came from the dye, for it must be remembered that mohair plushes are woven "in the white," and afterwards (perhaps several months or a year) are dyed according to instructions to fill orders. Kemp, at this stage of the process, becomes an expensive proposition, for skillful hands must burl out every fiber of it as well as every other bit of foreign substance. In the cheaper plushes, such as are largely used in street cars, there is a considerable quantity of kemp. Much of this material may also be used without detriment in the manufacture of rugs.

The problem of the mohair manufacturer is the same as that of the mohair grower—how to get rid of kemp; and the burden of his meditations is to devise some sort of machinery that will do the work perfectly. American ingenuity has so far failed to invent such a machine, and so the manufacturer finds it necessary to call upon the breeder to produce mohair without kemp.

But the fact remains that the mills must get rid of kemp in some way, and the device which they use for the purpose is a machine which combs it out; but while the comb is removing the kemp it removes at the same time every mohair fiber of equal length with the kemp. This means that if the mohair going into this comb has kemp 3 inches long, all mohair fibers up to 3 inches in length must go out with it. The result is heavy loss. True, there is a use for this mixture of kemp and short mohair, as heretofore stated, in the manufacture of cheap goods, such as horse blankets and filling for carpets, and also for stuffing saddles.

## DURABILITY.

The durability of mohair and mohair manufactures is well known to those who are familiar with their use. Statements which to some may seem incredible are on record, but there is no good reason to doubt their accuracy. Ladies who have worn mohair crepons and brilliantines are all aware of the wonderful durability of this fiber.

Strange as it may appear upon first thought, it is the durability of mohair dress goods that has prevented their more extensive use heretofore. The first cost being somewhat high, they have not generally been worn by people of limited means whose principal aim is durability in the purchase of clothing. They have been subject to the caprices of fashion, being "all the style" one year and "out of style" the next. This has naturally restricted their use largely to that class of people who could afford to discard them before wearing them out.

Even though the first cost of these goods may be high, their use would prove economical for that class of people who desire good quality and good appearance without affecting the highest degree of fashion. They will preserve their color to the last and the luster will never disappear.

## PRICES.

Mohair prices have a wide range and are influenced to some extent by prevailing fashions. The demand for mohair of good quality has been steady and constant during the past few years, and so many staple articles are now manufactured from it that fleeces of good quality, clean, and uniform in length, find a ready sale. Mohair that is dirty, kempy, and short will bring as low as 7 cents a pound. During the last year (1905) fancy prices have been paid for mohair over 12 inches in length by manufacturers of specialties, such as wigs, flowers, hair nets, etc. The average price of mohair of one year's growth for 1904 and 1905 was 34 cents a pound.

The following instances are given of remarkable mohair yields and prices: Among the Angora goats exhibited at the Louisiana Purchase Exposition in October, 1904, were two goats which, because of the long fleeces that they carried, attracted more attention than any others of the prize winners. One of these was a doe owned by Mrs. M. Armer, of New Mexico; the other, Kingston Lad, was the property of Tom Wedgwood, also of New Mexico.

Mrs. Armer's doe sheared 14 pounds. The length of the staple is not stated, but the longest of it was about 18 inches. The mohair was sent to a purchaser in New York City who fixes his own price upon long mohair. He buys all he can find in this country and imports largely besides. He uses the hair in the manufacture of various things, such as wigs, switches, nets, ornaments, flowers, etc. The following was his payment to Mrs. Armer:

| | |
|---|---|
| 2 pounds, at $5 | $10 |
| 7 pounds, at $4 | 28 |
| 5 pounds, at $1 | 5 |
| Total | 43 |

Mr. Wedgwood's buck sheared 16 pounds. Ten pounds of this he sold to the gentleman already referred to at $5 a pound. The owner says he gave away ringlets from the buck at St. Louis to the amount of 2 pounds at least. Most of the fleece was over 20 inches long.

In this connection it is interesting to note that a considerable number of persons in various parts of the country have sold whatever very long mohair they raised for very high prices—all of it to one man. For instance, William Riddell & Sons, of Oregon, sold 25 pounds for $42, as follows:

| | |
|---|---|
| 3 pounds, at $3 | $9.00 |
| 5 pounds, at $2 | 10.00 |
| 15 pounds, at $1.50 | 22.50 |
| 2 pounds, at 25 cents (waste) | .50 |
| Total | 42.00 |

The Northern Angora Goat and Live Stock Company, of Montana, recently received from the dealer in long mohair $6.50 a pound for 42 pounds, a total of $273. This is the highest price on record and indicates that the mohair was remarkably long and fine.

It seems that there would be a limited demand for mohair for the purposes for which this very long staple is used. So long as there is a demand for a particular quality of mohair at such great prices the breeders will be wise if they endeavor to supply it.

## MANUFACTURES.

The first striking feature of mohair manufactures is their great beauty. The luster of the hair, which is so pronounced even while it grows upon the goat, remains in the manufactured goods, and no amount of washing and no character of dye will remove it. It aids the dyes to show their colors more effectively and imparts to the goods the pleasing property of changing shades in shifting lights, which is a feature quite characteristic of silk goods.

A second feature of importance is that the dyes are usually fast, and however much such goods may be exposed to the elements they will not fade. In the best mills fugitive dyes are not used except when an order is received to match a sample which has been treated with such dyes; for a fugitive dye can not be matched by a fast one, nor can a fast dye serve for a fugitive one.

The durability of mohair goods has been discussed in connection with the durability of the fiber composing them. It is a characteristic that ought to make their use economical in many ways. This should be the case especially with dress goods and other wearing apparel.

Mohair manufactures already have a very extensive use, but they appear in the stores under so many trade names that only a few people, comparatively, know that they are the product of the Angora fleece. These manufactures are so varied and the fiber adapted to so many things which are now made of wool or cotton that no attempt will be made here to give a complete list of them, but a recital of some of the principal uses of mohair goods will be made in order that it may become generally known how extensive is their use at the present time, and some idea formed of the possibility of extending the use of mohair to other lines of manufacture.

By far the most important product of mohair manufacture is plushes. It is a fact not generally known that practically all of the plushes used in railroad passenger cars are made of mohair; so also are the plushes used in street cars.

Besides the car plushes, which are usually plain, large quantities of frieze and crush plushes are used in upholstering furniture. The designs for the frieze plushes are limited only by the ingenuity of man. The skill of the fabricator is so well developed that the threads forming the designs are in loops and of different color, yet the whole is woven at one time "in the white" and afterwards colored in the same dye. The crush plushes are very handsome, showing to best advantage the effects of varying lights upon solid colors. This kind is largely utilized in upholstering armchairs, but finds large use also in other kinds of furniture.

The carriage robes, couch covers, sofa-pillow covers, and rugs are distinguished by their high pile and rich coloring. The pile upon the carriage robes and sofa-pillow covers is about half an inch high. The robes sometimes have the pile on one side only, but many are made with the pile on both sides. The coloring is most exquisite, as is true of the sofa-pillow covers and couch covers. These colors are printed on by hand after the pieces are woven, and are rendered indelible by long steaming. Rugs necessarily require more modest coloring, but all the richness of subdued colors and luster remain to make them a distinctly beautiful as well as useful ornament. These goods can hardly fail to attract attention and advance in favor.

Most of the so-called astrakhan now in use is made of mohair. It has all the beauty of the real article, is much more durable, and will never change its shade in sunlight or air.

It would be very difficult to enumerate the many ways that mohair might be used in manufactures. Besides plushes, which form the principal item, there may be mentioned dress goods of various designs, coats and coat linings, table covers, etc., which are already on the market. There is a growing demand for it in cotton-seed oil manufacture as press cloths, because it stands the strain of pressing particularly well. A suggestion has recently been made that mohair could be manufactured into tent and sailcloth and rain coats, having as its qualifications durability, lightness in weight, and immunity from molding. Mohair cloth will not only turn water, but will hold water like a skin if the water is not beaten through it. Tent and sail cloths would necessarily be heavier and be even more effective in turning water. It is argued that the extra cost of this kind of cloth for these purposes is more than compensated for in the matter of durability and lightness of weight.

## MARKETS, FACTORIES, IMPORTS, ETC.

There is a good market for all the mohair of the best quality that can be produced in this country. The demand for the best grade of mohair is far greater than the supply, as is shown by the fact that four of the leading mills purchased over a million pounds of imported mohair in 1907. There are more than a sufficient number of factories in this country to manufacture the product. These are all in the East, and the principal markets for mohair are New York and Boston. The marketing center of the world is Bradford, England, where practically all the product of Cape of Good Hope and Turkey is sold.

Some of the producers in the Northwest sell to commission men in Portland, while others sell in San Jose, Cal. A large amount of mohair used by the mills is purchased direct from the producers.

The proprietors of one of the leading mills stated recently that in 1907 they purchased about 90 per cent of their domestic mohair from the producers. Two other leading mill firms stated that they purchased, respectively, about 50 and 30 per cent direct from the producers.

The following table gives the quantity of domestic and imported mohair used by five leading mills in the United States in 1907:

*Quantity of domestic and foreign mohair used in the United States by leading mills in 1907.*

| Mills. | Domestic. | Imported. |
|---|---|---|
| | *Pounds* | *Pounds.* |
| Sanford Mills, Sanford, Me | 1,219,653 | 461,934 |
| Cranston Worsted Mills, Bristol, R. I | 38,000 | |
| Massachusetts Mohair Plush Co., Lowell, Mass | 600,000 | 839,000 |
| Tingue Manufacturing Co., New York | 350.955 | 11,150 |
| Queensbury Mills, Worcester, Mass | 453,880 | 30,184 |
| Total | 2,662,488 | 1,342,268 |

As shown by the following table, an enormous quantity of mohair is imported annually from Turkey and South Africa into the United Kingdom, from which center of the mohair trade Germany, France, Holland, Belgium, and our own country are purchasers.

*Imports of mohair into the United Kingdom from British South Africa and Turkey, 1901 to 1907.*

| Year. | British South Africa. | | Turkey. | | Total. | |
|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| | *Pounds.* | | *Pounds.* | | *Pounds.* | |
| 1901 | 10,615,948 | $3,345,840 | 9,102,352 | $3,032,204 | 19,718,300 | $6,378,044 |
| 1902 | 18,241,579 | 5,288,090 | 11,518,629 | 3,634,390 | 29,760,208 | 8,922,480 |
| 1903 | 15,755,572 | 4,752,132 | 12,131,343 | 3,866,653 | 27,886,915 | 8,618,785 |
| 1904 | 13,984,345 | 4,327,457 | 10,809,928 | 3,377,137 | 24,794,273 | 7,704,594 |
| 1905 | 12,532,482 | 8,795,709 | 12,524,356 | 3,931,650 | 25,056,838 | 7,727,359 |
| 1906 | 15,704,894 | 4,748,905 | 10,508,221 | 3,299,589 | 26,213,115 | 8,048,494 |
| 1907 | 19,125,425 | 5,926,803 | 11,652,140 | 3,798,907 | 30,777,565 | 9,725,710 |

Judging from the official figures of the United Kingdom, the Turkish mohair brings a slightly higher price than the South African hair. This statement is corroborated by Mr. S. B. Hollings, an authority on the mohair trade of the world. From 1901 to 1905 the difference in price per pound was a little less than 2 cents, in favor of the Turkish hair.

The tariff act approved July 24, 1897, places a duty of 12 cents a pound upon mohair imported into the United States. Mohair cloth for buttons is taxed 10 per cent ad valorem. The duty on dressed and finished goatskins is 20 per cent ad valorem; on skins for morocco, tanned but unfinished, 10 per cent ad valorem. These rates are subject to increase under certain conditions of shipments.

## THE MEAT.

There is a decided prejudice against the use of goat's meat among people who are ignorant of its qualities. The flesh of the Angora is exceedingly nutritious and palatable. The flesh of the kids is considered very fine. Breeders who pasture their goats upon grass as well as upon browse, and then fatten them with grain, produce a meat so nearly like the best lamb that it requires an expert to detect the difference. These people use the term "Angora mutton." In other instances, where goats are fattened by browse alone, there is a decided game flavor imparted to the meat, and under these conditions it is called "Angora venison."

In Cape Colony it is said that the old does are slaughtered to furnish meat for farm hands, and young wethers are sold to butchers in the town. In California many miners purchase Angora wethers in preference to sheep wethers for salting down for winter use, because, as they state, the Angora meat contains less fat, is more easily kept, and is just as palatable. In Arizona and New Mexico goat meat is used by many people.

The market for mutton goats has been much better during the past year than formerly, and this adds much encouragement to the Angora breeders. The edibility of goat meat is becoming more generally understood, and the use of this meat is increasing, as shown by the number of Angoras slaughtered annually at the principal markets, 58,183 having been handled in Kansas City alone in 1907. Kansas City is the leading market for mutton goats in this country, and most of the goats sold there are received from the Southwest. One of the leading commission companies handled over 17,000 head of Angoras in 1907, practically all from Texas, averaging 82 pounds, and selling as high as $5 per hundred pounds.

The meat of the Angora is sold as goat meat on the market and does not sell as high as mutton. Formerly goats passed as sheep and their meat was sold to consumers as mutton.

## OTHER PRODUCTS AND USES.

### SKINS.

The skin of the Angora is of a more delicate texture than that of the common goat, and consequently is not suitable for shoe leather. The Angora skin will not bring as high a price in the market as the common skin on this account.

The skins of the Angoras, if taken when the hair is about 4 inches long, make very handsome rugs. The hair retains its original luster, and may be used in the natural white or dyed any color desired. The pure white ones are more generally preferred. There is a demand for Angora rugs in the United States which so far has not been supplied by domestic production. These rugs can be purchased at prices ranging from $4 to $8.

Another article of manufacture from the skins is the carriage robe, rivaling in beauty and durability the buffalo robe, which is no longer a factor in the market. The smaller skins of the does and wethers and the kid skins find a use as robes for baby carriages and are exceedingly attractive in their brilliant white.

These skins are used largely in the manufacture of children's muffs and as trimmings for coats and capes. They are also being used for men's coats and gloves. The finest kid fleeces adorn the collar and border of some of the ladies' opera cloaks. In the stores they are sold often under some peculiar name which does not inform the purchaser that they are ornamented with the hair of the Angora goat, and so thousands of such articles are worn by people who are unaware of the true name of their "furs."

Skins having fleeces are admitted free of duty, but a tariff rate of 12 cents a pound is placed on imported hair and a tariff of a varying schedule is placed upon manufactured mohair.

## MILK.

The Angora is not primarily a milch goat, and is not often employed for that purpose. The information at hand indicates that the quantity of milk given by an Angora doe is uncertain, and only in exceptional cases does the amount approach that given by the established breeds of milch goats. Some of the records of the earlier importations of Angoras into the United States show that some of them were milked with success. It is stated upon the authority of some of the oldest breeders in the country that the likelihood of finding a good milch goat among Angora grades diminishes as the breeding of the goat is improved.

An analysis of goat's milk for the British Goat Society, with an analysis of cow's milk for comparison, is shown in the table below.

*Comparison of analyses of goat's milk and cow's milk.*

| Element. | Goat's milk. | Cow's milk. |
|---|---|---|
| | *Per cent.* | *Per cent.* |
| Water | 83.21 | 87.56 |
| Butter fat | 7.30 | 3.63 |
| Casein | 4.18 | ........ |
| Milk sugar | 4.10 | 8.81 |
| Ash | 1.21 | ........ |
| Total | 100 | 100 |

The milk has an additional value in that the animal is practically immune to tuberculosis. Less than a dozen cases of tuberculosis in goats are recorded.

### PROTECTION FOR SHEEP.

There is very little complaint heard from breeders of Angora goats concerning the ravages of dogs, while sheep raisers have always to recognize dogs as foes. Bucks can be trained to fight dogs, and thus be a protection to sheep. A few goats will stay with a flock of sheep, but if there are many of them they will be apt to separate themselves.

### ANGORAS AS PETS.

The purebred Angoras are very graceful, and their beautiful shaped bodies and fine silky hair make them very attractive. As pets for children they are very popular, if they can be kept where they will be harmless to vegetation and anything made of cloth. They have all the propensities of the common goat for destroying fruit trees and chewing any kind of cloth and of climbing upon roofs. The Angoras are tractable and are often harnessed to carts, as are common goats, and their beauty makes them more desirable for this purpose.

### ENRICHMENT OF LAND.

The droppings of sheep and goats are about equal in value as a fertilizer, and it is certain that the goat produces as much as the sheep. There is no better fertilizer for fruit trees and lawns than goat or sheep manure.

Mention has already been made of the value of the droppings of goats upon land that has been cleared of brushwood. If goats are kept upon land for a year or more, the benefit derived from the manure will be very considerable, not only upon land that has been cleared of brush, but also upon cleared land overgrown with weeds.

## LOCALITIES ADAPTED TO ANGORA GOAT RAISING.

So far as temperature is concerned, no place has been found that is too hot or too cold for Angoras. Although not partial to heat, they will stand it quite as easily as sheep. Shade is essential to success if the sunshine is very warm.

The climate in Angora, where the breed originated and is still supposed to flourish in its most perfect state, is extreme. A temperature as high as 85° F. is registered in the summer and as low as 0° F. in the winter. In Cape of Good Hope, where they are thriving well, the temperature goes higher in the summer, but not so low in the winter. The United States presents a wider range of temperature, where, in southern Texas and New Mexico, it may go above 100° F. in the summer, and in Idaho as low as 30° F. below zero in winter.

Almost any kind of soil, except wet and marshy land, is suitable for these goats. Their preference is mountainous or rocky land, where they find it necessary to climb mountain sides and rocky cliffs to browse. Such situations not only afford them satisfaction in climbing and feeding, but the rocks serve to keep the feet trimmed.

One of the reasons for the freedom of goats from most diseases is that they require pure water, and in no place is better water found than in the springs and rivulets of hilly or rocky localities. Goats also require much exercise, much more than sheep, and such situations satisfy the inclination.

Lowlands that are wet or marshy are not at all suitable. The effect of such situations soon makes itself apparent in a flock of goats. Foot rot is apt to give endless trouble, and the feet will need much attention in other respects. However, it must not be understood that rocks and hills are essential, although they provide for the goat an ideal situation.

The habits of goats, as set forth in the earlier paragraphs of this paper, suggest at once to the informed person that there are in the United States millions of acres of land suitable for goat culture which are now serving no economic purpose whatever. Much of this would answer for sheep raising, but much more of it is suitable for goats only.

There are many acres of farm land in this country covered with brush which are well adapted to Angora raising. The worn-out farms of New England furnish an excellent field for these animals, and at this time there are many small flocks of from three to fifty goats in that section exterminating the brush and fertilizing the soil.

In the South, where there is an increasing interest in live stock raising, there are many thousands of acres of rough mountainous land so densely covered with brush as to be of no practical use. Much of it if cleared would provide excellent pasture. Reports have come to this Bureau of a considerable number of Angoras that have been taken into the South and are doing well.

The " stumpage " districts of Michigan and Wisconsin, where there are great areas of land of the best soil covered with brush, would, if cleared, be converted into good pasturage for sheep and cattle. Large flocks of goats have been put upon much of this land and are clearing it, producing mohair, and enriching the soil.

Angoras have been tried in the Northwest with success. Some of the finest and best goats in the United States are raised in Oregon.

n Montana, Washington, and Idaho, where there is an abundance of vailable land, Angoras have been tried and have proved a successful enture. In Montana the grazing problem is receiving attention, and t is quite probable that the value of grazing land for goats will be onsidered in other Western States. While goats prefer brush and veeds, they will readily eat grass and thrive on it.

The largest flocks of the country are in the Southwest, principally n Texas and New Mexico. In this section there is a vast area well dapted to the industry. On account of the mildness of the climate, vinter housing is unnecessary.

The Ozark region is also well adapted for Angoras, and reports in-licate that a number of breeders of goats have taken advantage of hese favorable conditions.

## BUILDING UP A FLOCK.

It is assumed that whoever goes into the business of raising Angora goats does so for the production of mohair rather than of meat or skins, and so it is to his interest to have a flock that will yield a profit from the beginning. The best flock for this purpose is one composed of purebred animals. Such a flock will yield good mohair from the first.

Those who enter upon the business of goat raising, however, must make their operations conform to their capital, the same as in any other business. They will find that desirable does will cost from $8 to $15 each, and bucks all the way from $50 to $100 each; so that a large herd of this kind, although preferable, will cost a small fortune, and is beyond consideration by most people who will engage in the industry.

Another plan that may be pursued by one who has limited capital, but time and the patience to wait, is to begin with a few first-class animals and build up a flock from these. The result will be satisfactory, and the only drawback is the length of time required.

Many of the large flocks of Texas and New Mexico have had Mexican does for their foundation. Building up a good mohair-producing flock upon this plan requires five or six years. The advantages are that the does with which the beginning is made are cheap, costing from $1.50 to $2.50 per head. During the first and second crosses there are many twin kids, thus increasing the herd in that proportion—a condition not existing, except to a small extent, among purebred Angoras; the size and hardihood of the progeny are increased and the liability to disease decreased.

However wise the practice may have been, that method of building up a flock of fleece-bearing goats is now in vogue but slightly, if at all. The practice flourished best when the goat raisers knew very little of the larger prices they might have obtained for a better grade of mohair. Care should be exercised in starting a flock by this method to select only such common does as are entirely white; any other color, however slight, is objectionable. In handling the crosses the breeder often finds that atavism becomes apparent when it is most objectionable. For instance, the progeny for two generations of a doe having black spots might appear all that is desirable, while the third generation would produce the latent color.

It is always quite necessary that the common does should be of the short-haired variety. Long-haired ones will give trouble in persisting to throw out long hairs among the mohair.

The buck used upon these does should be the best one can afford. The better the buck, the better the result. As the fleece upon the first cross is not worth more than the effort to clip it, the males among them should be castrated when about 2 weeks old and disposed of for meat as soon as old enough. The females among them, being half-blood Angoras, are kept for service with another purebred buck. The result of this second cross is three-quarter blood Angoras. The mohair from them has a marketable value, but is very limited in quantity and usually mostly kemp. It is best to deal with this cross in the same manner as with the first cross. If this method of procedure is followed up to the fifth or sixth cross, a flock will result that will produce most excellent mohair.

It has no doubt occurred to the reader that we now have four or five different grades of does, beginning with the common breed. Therefore, after a high-grade flock has once been produced in this manner, each year brings forth another one from the same sources, and this condition continues as long as the breeding life of the does continues.

While the foregoing paragraphs tell of crossing upon common stock, it is a practice that is not recommended and should be discouraged at this time. Breeders are doing their utmost to produce an animal that is free from kemp, and this method of crossing upon common stock works against that purpose.

## MANAGEMENT OF A FLOCK.

### AGE FOR BREEDING.

Goats of both sexes will sometimes breed when they are 5 months old, and often at 6 months, but from the fact that they are at this age but a month or two from weaning time and are not nearly full grown, it is obvious that they should not be permitted to breed. They reach maturity when about 16 or 18 months old, and they ought not to breed before this time. If bred earlier the kids will not be so strong or so well developed. The goats are in their prime when from 2 to 6 years old, but with proper feeding in winter they have been known to breed regularly until 15 years old. The average life of goats, however, is about 12 years. There should be no tendency to keep does until they are very old unless they bring kids of exceptional merit, for it must be remembered that their mohair gets coarser, and consequently less valuable, as they grow older.

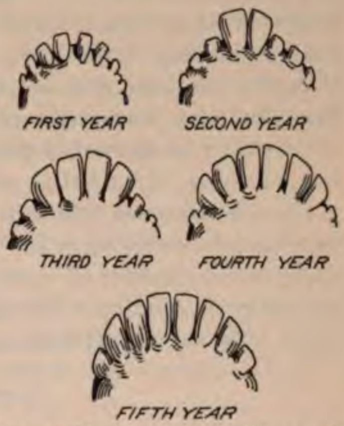

FIG. 8.—How teeth show the age of goats.

The accompanying illustration (fig. 8) shows how the age of goats may be determined until they are 4 years old. After that, in the absence of definite information, the age is a mere matter of guess, based upon the general appearance of the animal. The new teeth are longer and larger.

### IN-AND-IN BREEDING.

In-and-in breeding means the breeding of related individuals. The term is indefinite, and with some refers to a close relationship and with others any degree of relationship. There is an overwhelming sentiment against the breeding of individuals of close relationship, because of the injurious effects upon the constitution of the progeny. It is quite generally agreed, however, that this practice will give a fleece of finest fiber, having a beautiful luster and little oil, but the weight will not be so great. Those who favor the practice contend that the quality more than offsets the quantity. Col. Richard Peters, the most successful breeder of his day, said that half-blood does can with best results be bred to their own sires, provided the sires have proved themselves to be good breeders.

### MANAGEMENT OF THE BUCK.

Bucks usually come in heat about the middle of July and continue so about six months; does, however, do not usually come in heat until the latter part of August or the first of September. As the period of gestation in goats is from 147 to 155 days (or about five months), care must be taken in mating the animals in order to have the kids dropped in proper season, which will vary somewhat with the locality. The kids should not come before the warm days of spring, or when vegetation begins to put out vigorously. Therefore the buck should be put to service from November 1 to December 1, so that the kids will come about the 1st of April or May. The only objection to earlier kidding is the extra care required to preserve the life of the kids, for they are, like lambs, quite delicate for a few days, and exposure at this season should be avoided.

A buck, like any other domestic animal, should be in the best possible condition when put to service. He should be well fed with grain for a few weeks before this time, and the feeding should be kept up until a few weeks after his service is ended.

As to the number of does which a buck may serve, there is a great diversity of opinion. The greater number of goat raisers, however, think 40 or 50 are all that may be served with good results.

## NUMBER OF KIDS.

Purebred Angora goats do not often drop more than one kid at a time, while the common goats nearly always drop two. There are many twins with the first cross, but the number diminishes as the crosses become higher. It is stated that the purebred Angoras never dropped but one at a time, and that the presence of twins in a flock is evidence of a base origin of the goats. The latter statement is disputed by some, who believe that the purebred Angora (having no trace whatever of base blood) will drop twins as regularly as the common goat. Good handling of a flock ought to give a kid for every doe, and there are instances of an increase of 120 per cent in a flock. In the Southwest, where the flocks are very large and on ranges, and where no particular care is given at kidding time, the percentage of kids is about 70.

## KIDDING AND THE KIDS.

For two or three days after the kids are dropped they are naturally quite delicate, and there will be no future success unless good care is given at the time. They can not "rough it" at this period, though after a few weeks, when the kids are large enough to follow the flock, they will be able to care for themselves very well.

The proper time for kids to arrive is in the spring, about the time when leaves start on the trees and bushes. At that time there is milk-producing food for the doe, and the weather is also warm enough to favor the kids. The exact time may be governed, of course, by the service of the bucks, and will be earlier in localities where the seasons are earlier. If kidding comes in cold weather, there will be greater difficulty in saving the kids. Warm stabling must also be provided.

and the does will require extra feeding in order that they may supply milk for the kids.

A few days before a kid is due the doe should be separated from the flock. Some breeders would put her in a pen alone, while others would put as many as 20 in one pen. If the facilities are at hand, a small pen for each doe is better, for the reasons that the doe will sooner " own " the kid and there will be less danger of injury than if among a number. A doe knows her kid by the sense of smell, especially when it is young.

If kids are dropped on the range or in the pasture, they must be carried home and special care given to see that the does are made to own them, for many times they will refuse. A lamb will follow its mother very soon after it is dropped, but a doe will hide her kid as best she can in bushes, or behind a stone or log, and leave it there while she goes away to feed, and on her return she expects to find it where she left it.

The following is from " California Angoras," published by C. P. Bailey & Sons Company:

> There are in use two methods of handling kids at kidding time—namely, the corral method and the staking method. Each of these has points which render it most valuable under certain conditions and in certain localities.
>
> ### The Corral Method.
>
> This method may be used with any number of goats. With various modifications and adaptations which best suit the size of the flock, the climatic conditions, the facilities for feeding, etc., it may be used by the beginner with success. We have practiced this method in Nevada for more than twenty-five years. If the herd is a large one, say 1,000 head, three men are required to handle the goats at kidding time. The service of the bucks is so managed that the kids will be dropped gradually through several weeks. At the height of the season we expect from 75 to 100 kids a day. The season lasts about thirty or forty days. Fortunately, most of the kids are dropped in the daytime.
>
> We have four or five small corrals fenced with 36-inch woven wire and large enough to hold 50 does and their kids. The doe should be allowed plenty of room, because if too close to her neighbor she may adopt the other doe's kid. Besides these small corrals, two large ones are needed, each large enough to hold 1,000 does. Along the fence of one of these corrals are a dozen small pens just large enough to hold a doe and kid. At the gate of this large corral a jump board is placed. This jump board is intended to keep back those kids which are not large and strong enough to jump over it. A 2-inch board about 18 inches high will answer the purpose. Another device sometimes used is a platform open at the end, so that the kids may run under it, and thus avoid being trampled upon when the goats are going out over the platform.
>
> The small corrals may be made of panel fence and located in a meadow where some feed is afforded. The does should always have some kind of feed at kidding time.
>
> In the morning the flock is carefully examined, and all does which show signs of kidding during the day should be separated and placed in one of the

small corrals. The large flock is now turned out, and one of the men is sent with them, with instructions to take the herd at once as far as he intends to go for feed that day, and then to let them feed over a limited area and gradually work their way home. A few does will drop their kids on the range and the herder should carefully note the number and their location. He should see that the herd does not feed around one of these does, as she is apt to leave her kid and join the band, thus necessitating much extra work in finding the kid and in giving it to its mother. Early in the afternoon the band is placed in one of the large corrals. Now, the herder and another man go out with a wagon or on foot and carry the kids home, gently driving the mothers. The kids should not be handled or rubbed against one another more than is necessary, as the doe knows her kid by the scent. These does and kids are placed in the small corral which contains the does held back in the morning with the expectation that they would kid during the day. We now have one day's kidding in one of the small corrals. The does and kids should be watched to see that they are properly arranged. Do not bother them more than is absolutely necessary. Do not be in a hurry to make a doe own a kid. Do not drive the goats around one of the small pens.

The does should remain with their kids in the corral for a day or two at least, or until the kids are properly mothered. Any does which have not kidded should be taken out. The next morning any kids which may have been born during the night are put in another small corral with their mothers, as well as the does which are expected to kid during the day. The procedure of the previous day is repeated. In about three days, if one has limited quarters, the first day's mothers and kids may be put in the second large corral—that is, the one with the jump board at the gate. Now this "wet" band is placed in charge of one of the men and sent out to feed. The gate is opened, the mothers passing out over the jump board, and the kids remain in the corral. The herder must not range his goats near the does that are kidding upon the range, and he should be cautioned to come in later than the "dry" band, so as to avoid any possibility of their mixing. When his band arrives at the corral, the gate is opened and each mother hunts for her kid. Some of the kids may not find their mothers, and if after a day or two there are a few unnourished kids and some does with overdistended udders they should be placed together in the small pens along the side of the corral. The doe will own the kid in a day or two whether she is its mother or not. The kids should not be allowed to become too weak before this is done. If one does not have enough small pens, a doe may be held while two or three kids suckle her, and thus tide them over until some of the small pens are vacant.

The next day the second day's kidding is added to the wet band. The wet band thus gradually grows, while the dry band decreases. During the day two men will be employed at herding the dry and wet bands, respectively, and the third man will be kept busy inspecting the kids, feeding the does in confinement, etc. If the weather is stormy, some of the kids will have to be sheltered. The advisability of having the kids dropped gradually through a period of thirty or forty days will readily be seen. If help is inexperienced, they may be gradually trained, or if the weather is stormy there will be time to get all things arranged properly.

The kids should not be allowed to go with their mothers until they are about 6 or 8 weeks old. If they go before this, they will probably become tired very soon and go to sleep. When they awake, the band will have gone and they are liable to be lost. During the day, while the mothers are feeding, the kids would eat a little grass if they could be herded near the corral.

As stated before, there may be many modifications of this method which will suggest themselves, but the above is a general outline of a method commonly in use.

### The Staking Method.

This method is largely employed, even with large flocks, in New Mexico, but is possibly best suited to small flocks. It is without doubt the best method for certain surroundings. About the same amount of help will be required as with the corral method. There should be a good supply of stakes similar to tent stakes. There should also be a supply of swivel blocks which are about 4 inches long and having a hole bored near each end. A piece of rope about 6 inches long is fastened to the stake and the other end is passed through one of the holes in the swivel block and a knot tied in the end. Another piece of rope of equal length is likewise knotted and passed through the other hole of the swivel block, the loose end being tied to the kid's leg. Any swivel will take the place of this primitive method. The herder or owner can busy himself during the winter months by making stakes and swivels and by cutting and attaching the ropes.

When a kid is born it is taken to a convenient place to stake, and the mother is gently coaxed to follow. The stake is securely driven into the ground, and the kid fastened to it by the hind leg. The mother is left with the kid, in order that she may know where to find it upon returning from feeding. The kid should be staked where he can get plenty of sunshine, shade, and shelter. A small bush, a post, or a box will answer the purpose admirably. If there are twins, they must be so staked that they can suckle at the same time. The rope should be changed from one hind leg to the other occasionally to prevent unequal development. Sometimes a vigorous kid gets thoroughly tangled and requires help.

The kid may thus be left staked until he is old enough to go with the flock, which is after six or eight weeks, or he may be put in a corral after a few days, as is done in the corral method.

There are many successful breeders who use this method entirely. One may expect to get good results if he follows either the corral or staking method carefully.

There is very small loss among kids cared for as set forth above. Many of the breeders on a large scale report the percentage of increase as 100. This does not mean that every kid lives, but that so few die that the loss is offset by the number of twins that are dropped.

The most practicable fencing to be used at kidding time is made of portable panels. By the use of these panels a pen may be made large or small and be moved from one place to another without difficulty and with very little work.

### Weaning.

Kids should not be weaned until they are 4½ months old unless they are very strong, but they should not remain with their mothers after they are 5 months old. This especially applies to the buck kids, as they will often breed at 6 months of age or even younger.

### Castration.

The buck kids not reserved for breeding purposes should be castrated when about two weeks old. The earlier it is done the bette will be the meat and the mohair. It is pointed out in previous page that the mohair from wethers ranks with that from the does, an the flesh is superior to that of the does and inferior only in smal degree to that of the kids.

## SIZE OF FLOCK.

All goat raisers agree that Angoras can not stand crowding together, and the higher the grade of the goats the more susceptible ar they to injury from crowding. But to state just how many shoul be kept in a flock is difficult, as the number depends upon the character of their restraint. Where they have the range at day and larg yards at night, the flocks may be very large, but where they have pastures and small pens at night the flocks must not be large. In the Southwest, flocks of from 500 to 1,000 are herded together.

Much stress should be laid upon the matter of overcrowding, as it is a more serious matter than is generally recognized. Goats will not stand what sheep do in this respect. They require much fresh air, and many persons who have taken their animals from the South to the North have done an injury to the flocks by providing barns that are too warm and that have not sufficient ventilation.

## CARE OF A FLOCK.

The preceding pages have no doubt given the impression tha Angora goats are very hardy, and, indeed, it is true, especially if thei foundation is upon crosses with the common goat; but this should no be taken by the careless or shiftless man as a license to subject hi goats to all manner of discomfort with the expectation that the result will be fully as satisfactory as if rational attention were given them That these animals can withstand extreme cold, such as that of the islands of Alaska, or extreme heat, such as that of Guadalupe Island is strong evidence of their fortitude and of their adaptability to wide range of temperature under proper care. That they can subsis upon vegetation which is utterly useless for any other purpose i evidence simply of their economical keeping; it does not permit on to conclude that they never need any other kind of feed at times. In a word, it is intended here to impress the fact that, if satisfactory results are to be obtained in goat raising, the animals must receive the same rational treatment that is received by other live stock when best results are sought.

Information which has been received by the Bureau of Animal ndustry through correspondence shows that the press, in its efforts exploit the good features of these goats, has to some extent exaggerated the facts. It seems to be a favorite saying that "they live on othing," and men who would not think of putting a horse, a cow, or hog upon its own resources in a pasture in winter where the snow ay be a foot deep have done so with their goats, and have wondered hy they did not thrive. The goat will browse just as eagerly in the inter upon soft twigs as in the summer, but the twigs must be within is reach.

Goat men of experience leave all trees which the goats can not estroy in the summer until the winter and then cut them down. It is a goat's paradise," as one correspondent states, to be in these tree ops. They will eat the soft part of the twig—2 to 4 inches. This feed for goats—and good feed, too—although it is such as no other ne of our domestic animals will subsist upon.

There is another feature of winter browsing which is of importance, d that is that the goats ought to enter the winter in good condition. for any reason they can not get into good condition in the summer d fall, when there is so great an abundance and variety of brush d weeds, little can be expected of them in winter on feed less in ntity and variety. On every farm where goats are kept some sort coarse fodder and grain should be provided in order that they may available at times when storms will keep the goats under cover.

No amount of cold will prove injurious to the goats, but the caution y well be repeated that they should be kept dry, especially in cold ather. A shed of easy access that will turn water is one of the ntials of goat raising. It should be so constructed that the water not drip from the eaves. It should not, however, be perfectly t, so that the air can not have the freest circulation. Many goats die from being too closely confined in warm sheds or barns bee their owners will realize the fact.

### HERDING AND FENCING.

Goats require a great amount of exercise, much more than sheep, e one is by nature a browser and the other a grazer, and the browshabit naturally requires more activity on the part of the goats. ey are sensitive to restraint and do better if not herded, but of rse this is often a necessity, and therefore should be done under as orable circumstances as possible. So far as possible they should t be allowed to feel their restraint. If constant attendance is cessary, the herder should be of quiet disposition. The next best ing to the freedom of a range is a large pasture, where the goats may have oversight, but not constant attendance. Such pastures are considered the cheapest method of keeping these goats. They can easily be trained to come home by feeding a little and salting regularly at home.

The fencing for pastures is a matter which early concerns one who contemplates going into the business, for it is the current belief that goats will climb onto any shed of ordinary height or jump any fence that will stop other animals. While they will climb anything that is built in such a manner that it may be climbed easily, they will not jump any ordinary fence. They will, however, creep through if there is an opening large enough. The old-fashioned "worm" fence, especially if it leans outward, will not stop goats. The angles in such a fence are an incentive and a delight to them.

In building a goat fence there are other matters to be taken into account than simply that the goats shall be kept in; the animals themselves (especially the young ones) must be protected from dogs and wolves from the outside. In the Southwest it is much more important to fence to keep "varmints" out than it is to fence to keep the goats in. So the double object must be kept in view in building a goat fence. Such a fence must be dogproof, hogproof, and wolfproof.

Fences made of any material may be suitable, but the manner of construction is the important feature. In order to convert brush land into pasture, a ten-strand barbed-wire fence, with posts set 16 feet apart and having two stays between, is a very good one. The lowest wire is only 1 inch from the ground, the next four wires 3½ inches apart, and one-half inch is added to every space above the first below it. Taut wires are very necessary. Woven wire, although somewhat more expensive than barbed wire, makes a much more satisfactory fence. A good fence may be made of woven wire 3 feet high, drawn on the inside of the posts, and a closely barbed strand of wire 3 or 4 inches above fastened to the outside of the posts to prevent animals from jumping in. A straight rail fence, if the rails are laid close enough, as well as an ordinary board fence, will turn goats. A five-board panel fence 4 feet high is sufficient for goats.

## SHELTER AND PENS.

A shelter is necessary during wet spells, and more especially if the rain is cold or in case of a sleet storm. Dry cold alone has little or no injurious effect after the kids are three or four weeks old, and they will even frolic in the snow when the mercury is at zero, and sleep with apparent comfort in an open shed. With their dense covering there is no reason why this should not be true; but this same dense covering, when soaked with cold water or driven full of sleet, is a ly menace. Goats will not get wet if they have an opportunity void it. They appreciate a shelter and will always seek it at t, and during the day in the event of storms.

ats should not be left on the range or in pasture overnight. The r is practiced to a considerable extent, but experience has shown they are safer in closer confinement during the nighttime.

e pens in which the goats are kept at night should, above all gs, be in such a location that they can be kept dry by drainage. e is little use in raising Angoras for their fleeces if they are com- d to wade through mud and filth, or confined under these con- ns. The fleece would soon become soiled and matted.

e sheds provided for their shelter must be of a size to give an dance of room. The goats should not, under any circumstances, owded together. If they are thus crowded in cold weather they pile up, with the result that some of the younger ones will die suffocation.

elter from the sun's rays should be provided for summer time. ough goats are able to withstand intense heat, they do not thrive when subjected to it.

## FEEDING AND SALTING.

e principal reason why goats will be raised instead of sheep in places is because they are practically inexpensive so far as feed- s concerned. This phase of the subject is quite fully discussed r the head of "Browsing and pasturage." They eat the leaves mmer and the soft twigs in winter, and if there is an abundance ther they will not require anything else to sustain life; but this ition exists only in certain localities, and other means must be ted elsewhere. They are fond of straw and fodder of any kind. twithstanding the ability of goats to subsist upon coarse fodder e winter season, the impression must not be held that they will e well upon it in the absence of browse. They will extract from fodders all the nourishment obtainable, which is not very great, must receive some supplementary feed. Any kind of grain will er this purpose. Probably the best feed is oats, and if it is sheaf better still. In Texas some of the large goat raisers feed cotton by scattering it upon the snow so that goats will have to exer- somewhat in picking it up; besides, the time consumed in picking he seed thus scattered insures better mastication.

owpea stubble in the autumn, otherwise used for fertilizer only, proved a satisfactory feed. Cowpea hay, clover hay, and alfalfa are all most excellent coarse feeds, and no grain is necessary with l of this kind to carry the goats through the winter.

In feeding grain care must be taken not to make the supply too liberal, unless the object is to fatten for slaughter. Goats easily become lazy on a plentiful supply of grain and will decline to go out to feed upon the brush. This is an important point, as their hardiness to a large extent is attributed to their feeding upon browse and to the resulting exercise.

To keep goats in good condition the quantity of feed necessary varies according to climate. A fair average would be one-fourth pound of corn or its equivalent in other grains and 1¼ pounds of hay at a ration. If an abundance of winter pasture is available, this ration fed once a day, preferably in the evening, is sufficient. If such pasturage is scant, they should have it twice a day, and on wet, cold, days when kept all day in sheds it should be fed three times or their rations should be made considerably larger.

Sugar-beet pulp has been fed with success. The goats must be taught to eat it, but after once learning they seem not to be able to get enough.

Goats will not eat soiled feed, as they are very fastidious in the matter of cleanliness of feed, and they have no inclination to stand in mud or filth, much less to pick their feed from it.

A running stream in a pasture is valuable, but if this is not present good water from a spring or well should be afforded.

Goats require more salt than sheep, owing to the more astringent character of their food. If loose salt is used, the general custom is to give it once a week on regular days. If rock salt is used, it should be placed where the animals can get to it at any time. Rock salt is preferable, as it can be placed in boxes or troughs raised from the ground, and thus be kept out of the dirt and be of easy access to the goats at any time; and, too, there is no waste and no danger that the animal will eat too much of it.

### MARKING.

Several devices for marking goats are in use, but the metal label in the ear is probably best known. A practice which appears to give satisfaction is to tattoo the numbers into the ear, using india ink. It is found that the metal label is sometimes pulled out by brush.

## DISEASES AND ENEMIES.

Goats are less subject to disease than sheep; but these species are so closely allied that treatment in cases of disease is the same for both. Several accounts have been published in the agricultural press of goats in the Southwest being affected with stomach worms and with grub in the head, the same as sheep are affected in the same localities.

The treatment recommended for the screw worm is as follows: dd to any one of the carbolic sheep dips 10 per cent of chloroform. pply this mixture, after thoroughly cleaning the wound, with a wad cotton. The chloroform immediately destroys the larvæ and the rbolic dip prevents the further blowing of the wound.

The stomach worm (*Hæmonchus contortus*) is the same form as und in sheep, cattle, and deer. The treatment in all cases is the me as for sheep.

Goats have at least three kinds of scab parasites peculiar to their ecies, but apparently only two kinds of scab develop. Psoroptic b of sheep does not develop disease upon them, though it can un- ubtedly sustain life for a while.

Tapeworms of the genus Moniezia are found in goats. In the in- tines are also found five roundworms, namely, *Nematodirus filicol-*, *Œsophagostomum venulosum*, *Strongylus hypostomus*, *Bunosto- m trigonocephalum*, and *Trichuris affinis*.

Verminous pneumonia occurs in goats as well as in sheep.

Tuberculosis is rare in goats. Their freedom from this widespread d insidious disease is probably due to the feed and climate where animals are found and to the exercise and fresh air obtained in ming over the pastures. When confined in close quarters with s that have tuberculosis, goats will also contract the disease; in er words, the goat's freedom from tuberculosis is due to environ- nt rather than to a natural immunity.

Goats in good condition are not likely to be diseased or to contract ease, but there are some maladies which affect them if they are mitted to get into poor condition.

Takosis, the disease which played such havoc in a few flocks a few rs ago, seems to have about run its course. The Bureau of Ani- l Industry took hold of the disease vigorously in 1902, and the ice given and the bulletin published have resulted in much benefit the breeders.

Takosis is probably not of recent origin, for as early as 1876 re- ts of losses of goats from a disease whose symptoms closely re- bled takosis were noted in the Country Gentleman.

The symptoms of takosis are somewhat similar to those accompany- a parasitic invasion of diarrhea and pneumonia. Listlessness d a languid appearance are the first to be noticed, with a slow, ble pulse and an elevated temperature. Snuffling of the nose and asional coughing are sometimes observed. The animals become y weak and are easily knocked down. The appetite is capricious, t rumination is seldom impaired. A fluid discharge of bad odor m the bowels is usually observed in the last days of life. The visible mucous membranes are pale and anemic, and respiration is labored and rapid. In no instance has the natural recovery of an animal been seen when once the symptoms of takosis were noted. All affected animals should be isolated immediately upon the discovery of the symptoms and a strict quarantine should be maintained as long as the disease remains on the premises.

Good results have been obtained from the administration of 0.10 gram doses of calomel twice a day for two days, followed by powders composed of arsenious acid, 1.40 grams; iron reduced, 12 grams; quinine sulphate, 6 grams, made into twenty powders, giving one to each adult goat morning and evening after the calomel. After an interval of two days this treatment may be repeated.

Goats are apt to have foot rot, but a cure is easily effected by the use of sulphate of copper (blue vitriol). It is usually applied by driving the goats through a trough containing a solution of strong blue vitriol. The solution should be about an inch in depth. Oscar Tom, a breeder of much experience, says:

> Butter of antimony applied with a stiff feather will cure it, or mix 1 ounce of sulphuric acid with 2 ounces of vinegar and apply as above. Go over the whole band. Generally one application cures if well done. Change the range at the same time if you can.

It is not a difficult matter, as all goat men agree, to rid goats of lice by dipping them in any of the common sheep-dip preparations. The animals can not thrive to the best advantage when they are carrying a fleece full of lice; sometimes the lice become so numerous as to cause the goat to lose flesh and finally to fail to produce a good quality of mohair, or even to produce a kid, if the infested animal is a doe. Goat raisers must learn that an animal which is badly infested with lice in the winter nearly always requires extra feed; in other words, if lice are raised, they insist on being fed.

The fact that many plants which are poisonous to sheep and cattle may be eaten with impunity by goats is frequently referred to by writers for the press. It is true, however, that goats sometimes die from eating poisonous plants. The so-called "ground ivy" is specially referred to. But it is believed that goats will not eat poisonous plants to an injurious extent unless driven by hunger to do so. Fatalities to goats from eating mountain laurel, previously referred to, are occasionally reported during the early spring months. As soon as other forms of vegetation become sufficiently advanced to afford the animals enough feed, they will refuse to eat the laurel and no more harm is caused by the plant until the coming of another season. Small quantities of laurel may be eaten without ill effect, and it is only when driven by hunger to the consumption of large amounts that any harmful results follow. The use of a drench con-

(B. A. I. 177.)

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 141.

# ULTRY RAISING ON THE FARM.

BY

D. E. SALMON, D. V. M.,
CHIEF OF BUREAU OF ANIMAL INDUSTRY.

WASHINGTON:
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1901.

# LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
*Washington, D. C., September 10, 1900.*

SIR: In accordance with your direction, I transmit herewith, for publication as a Farmers' Bulletin, an article on "Poultry raising on the farm," the same being a reprint from the Seventeenth Annual Report of this Bureau, which is now in press. It is believed that the suggestions contained in this bulletin, aided by the 31 illustrations which accompany the text, will be found useful on many farms.

Respectfully,

D. E. SALMON,
*Chief of Bureau.*

Hon. JAMES WILSON,
*Secretary of Agriculture.*

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# POULTRY RAISING ON THE FARM.

## INTRODUCTORY.

e barnyard fowls are regarded by most farmers as a very insig- nt part of their live stock; and yet, although so often neglected orced to shift for themselves, the poultry and egg crop constitutes e aggregate one of the most important and valuable products of rican agriculture. The conditions in this country are such that oultry industry is capable of inite expansion, and therefore to meet any demands that may ade upon it either by home or gn markets.

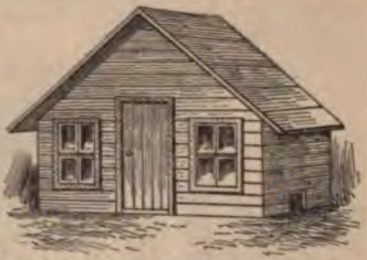


FIG. 1.—Implement house transformed into poultry house.

**portance of high-grade product.**— rder to secure a larger con- tion of poultry products per a in the United States, it is of e importance that there should s be an abundant supply of ly fresh eggs and of the best grades of table poultry. This tion is also a necessary factor in the development of the export . When the markets are filled with eggs which have lost their ty and flavor by long keeping, and many of which have acquired ensive taste; when the broilers and roasters offered to the consumer are thin, tasteless, tough, and altogether unfit for the table—it is not surprising that they are passed by, and beef, mutton, or pork taken in their stead. So, also, when the exporter is buying for consignment to foreign markets he must le to find at all times a good article of eggs or poultry in sufficient tity or he can not continue his trade.

.—Implement house transformed into poultry house.

**sibility of increased consumption.**—An increased supply of poultry cts of the highest class would unquestionably lead to an increased mption. There is no more staple and popular article of food, onsequently we may confidently expect the demand to develop

in proportion to the increase of our population and to the care
intelligence with which the markets are supplied.

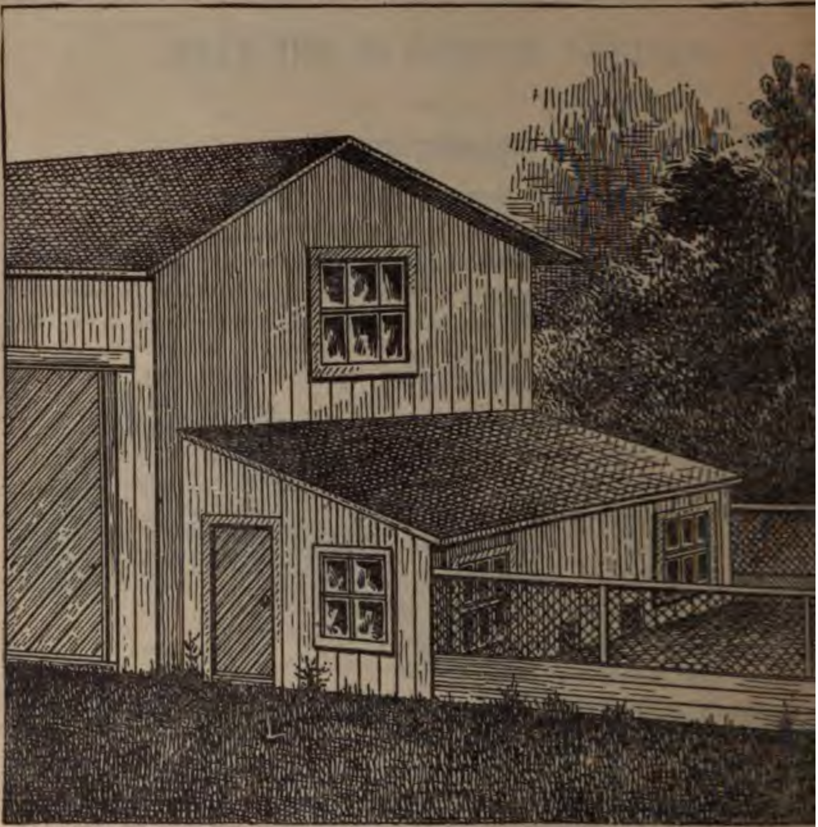


FIG. 3.—A lean-to poultry house.

**Increase of product.**—There is no stock on the farm that yield
better relative return to the food consumed than do the hens,
consequently it is well worth while
consider in what manner their prod
may be increased without disproporti
ately increasing expenses. The fowls must have comfortable and healthful quarters, they must have proper food and nesting facilities, but it is not at all necessary that there should be extravagant expenditures in supplying these.

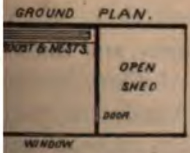
FIG. 4.—Simple form of poultry house.

FIG. 5.—Ground
of simple form
poultry house.

### THE KIND OF FOWLS TO KEEP.

The kind of chickens to be kept upon a farm depends almost as
upon the kind of man who manages them as upon any other conditio

e are no birds which stand neglect better than the common, mon- barnyard fowls, for these have lived and developed under unfa- le conditions and are accustomed ft for themselves. They are gen- hardy, vigorous, and yield a fair return in eggs or as table poultry; they respond fairly well to generous treatment, and, if selected with some care, are by no means to be despised, even when their product is compared with that of the standard breeds.



-Ground plan of poul- ouse with scratching

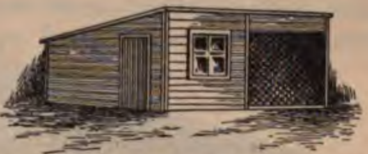


FIG. 6.—Poultry house with scratching shed.

## IMPROVEMENT OF BREEDS.

e improvement of the common poultry should begin in most by breeding from birds selected for their shape, size, and pro- veness, and by bettering the conditions of life under which they ept. If the owner is willing to go a little further and to bestow what more attention upon irds, he may cross them males of a standard breed, place them entirely by red males and females.

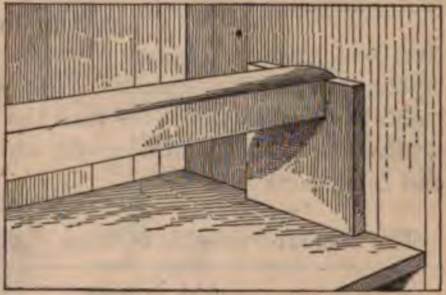


FIG. 8.—Construction of roosts.

## CARE OF FOWLS.

e standard breeds have brought to a higher plane velopment by extra care ore skillful management, if they are to maintain this improvement they must be con- d under the conditions which brought it about. They suffer more neglect and unhealthful surroundings than do the common fowls, se less accustomed to these conditions. The standard breeds, for these reasons, may not always give satisfaction, if their characteristics and requirements are not understood. If, however, the highest returns are expected which care skillful management can obtain, then a breed of fowls should be ed which has been bred for generations with this object in view.

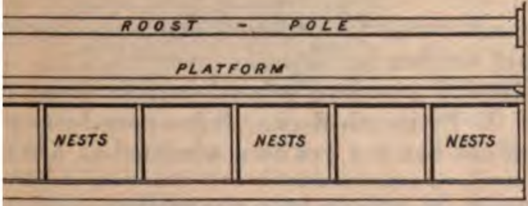


FIG. 9.—Sectional view of platform and nests.

## POPULAR VARIETIES.

The most popular fowls in the United States are the American breeds known as the Plymouth Rocks and Wyandottes. They are of medium size, good as broilers, good as roasters, good egg producers; the hens are good sitters and good mothers, and for these reasons they are known as general-purpose fowls. In the Barred, Buff, and White Plymouth Rocks, and the White, Buff, Silver, Golden, Black, and Partridge Wyandottes, there is a sufficient range of color to meet almost any taste.

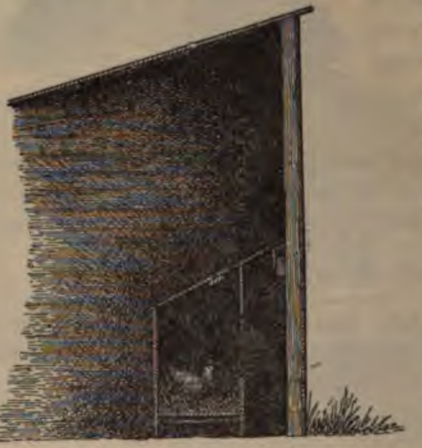


FIG. 10.—Sectional view of concealed or darkened nest.

## EGG PRODUCTION.

For farmers who desire fowls more particularly for egg production, the Mediterranean breeds, particularly the Leghorns, Minorcas, and Spanish, are to be recommended. The birds of these breeds are smaller, more active, and greater foragers than the Rocks or Wyandottes, and as layers they are unsurpassed. Should it be desirable, on the other hand, to raise heavier birds than the Plymouth Rocks, we should naturally turn to the Asiatic breeds, which include the Brahmas, Cochins, and Langshans.

## WEIGHTS.

The standard weights of these different classes are as follows:

| Breeds. | Cocks. | Hens. |
|---|---|---|
| | *Pounds.* | *Pounds.* |
| Plymouth Rocks | 9½ | 7½ |
| Wyandottes | 8½ | 6½ |
| Light Brahmas | 12 | 9½ |
| Dark Brahmas | 11 | 8½ |
| Cochins | 10½ to 11 | 8½ |
| Langshans | 10 | 7 |
| Minorcas | 8 | 6½ |
| Spanish | 8 | 6½ |

The Leghorns are smaller than the Minorcas and Spanish and have not been given standard weights.

The Rhode Island Red is a promising general-purpose breed, resembling in size and form the Plymouth Rock. It has been developed by crossing and selection, but has not yet been admitted as a standard breed.

## SELECTION OF STOCK FOR BREEDING.

Having in mind the size and peculiarities of the varieties of fowls to which reference has been made, it would appear to be a not difficult matter to select one which would satisfy the requirements of any farm. In purchasing breeding stock it is important to purchase from reliable breeders only, and to ascertain that the stock is in healthy condition and that it has been bred for early maturity, size, shape, and egg-producing qualities rather than for perfection of feathering. For the show room the feathering can not be neglected, as the judges often place it ahead of all other features of the bird's make-up; but for the farm the color and marking of feathers must be held subordinate to the utilitarian qualities. The feathers should not, however, be entirely neglected, as their perfection is an indication of the purity of blood and carefulness of breeding.

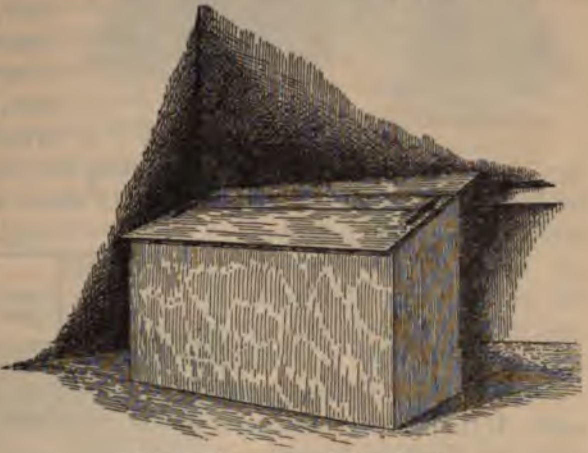


Fig. 11.—Concealed or darkened nest.

## POULTRY HOUSES.

It is very desirable that poultry should be provided with a house somewhat separated from the other farm buildings, but near enough to the barnyard so that they can spend a part of their time in scratching for and gathering up the many seeds and grains which otherwise would not be utilized. On farms where no poultry house is provided the hens are compelled to seek roosting places wherever they can find them—sometimes in fruit trees, sometimes on feed racks, sometimes on the farm machinery, or even the wagons and carriages. The result is not only untidiness, but fruit, feed, implements, and wagons are soiled and injured by the droppings, and sometimes vermin swarm in the roosting places to such a degree that the hens are voted a nuisance rather than a desirable part of the farm stock. If these vermin-infested places are near the horse stable, the mites may attack the horses, causing itching and a mangy condition of the skin, the origin of which is not always suspected.

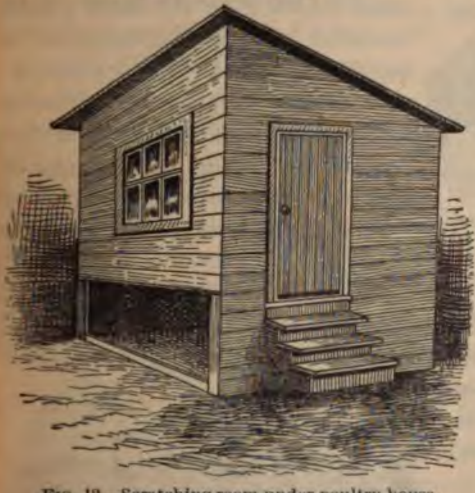


Fig. 12.—Scratching room under poultry house.

## PREFERABLE CONDITIONS.

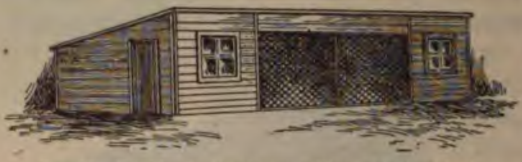


FIG. 13.—Double poultry house with scratching sheds.

Poultry houses need not be elaborate in their fittings or expensive in construction. There are certain conditions, however, which should be insisted upon in all cases. In the first place, the house should be located upon soil which is well drained and dry. A gravelly knoll is best, but, failing this, the site should be raised by the use of the plow and scraper until there is a gentle slope in all directions sufficient to prevent any standing water even at the wettest times. A few inches of sand or gravel on the surface will be very useful in preventing the formation of mud. If the house is sheltered from the north and northwest winds by a group of evergreens, this will be a decided advantage in the colder parts of the country.

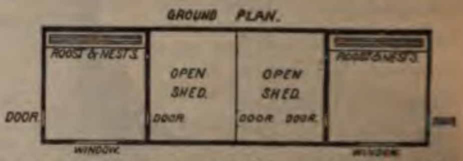


FIG. 14.—Ground plan of double poultry house with scratching sheds.

## UNUSED BUILDINGS.

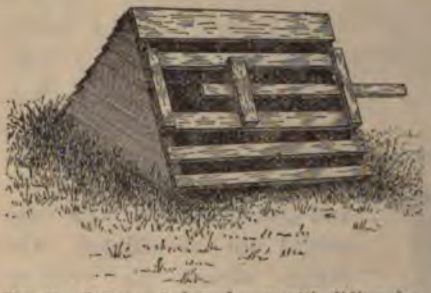


FIG. 15.—Common A-shaped coop with sliding slat.

Sometimes there is already a small building on the farm which has been used for implements or animals and which is no longer required for these purposes. Such a building may be easily fitted for poultry by cutting a small door in one side and placing roosts and nests in the interior. (Figs. 1 and 2.)

## INEXPENSIVE STRUCTURES.

In case there is no building suitable for remodeling into a poultry house, an inexpensive lean-to may be built (fig. 3), or a new building constructed. A house for this purpose should be planned with a view to simplicity, economy, and convenience, while supplying the conditions proper for successful poultry keeping.

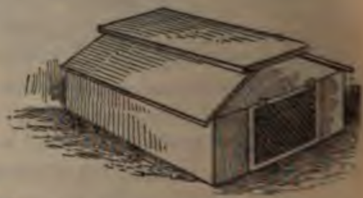


FIG. 16.—A common form of chicken coop.

One of the simplest forms of poultry house is shown in fig. 4, and ground plan of the same in fig. 5. A scratching shed may be attached to the side of this house, as in figs. 6 and 7, which, if desired, may be inclosed in front with poultry wire, so as to keep the birds confined.

## FITTINGS.

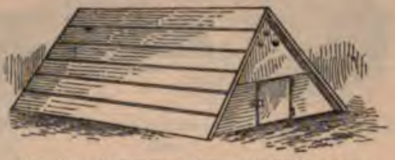


FIG. 17.—A common form of chicken coop.

**Roosts.**—The details of construction of roosts are seen in fig. 8. The portant points are a nearly flat or slightly rounded surface on the per side and as few cracks and vices as possible in which vermin y hide. The roosts may be made by 3 inch scantling and should be put in that they can easily be reved at any time for cleaning and nfection. A platform is often ced under the roosts to catch the droppings and the nests are placed der this platform. In a house, such as fig. 9, the manure platform may be dispensed with and the nest boxes placed along the front or sides of the building.

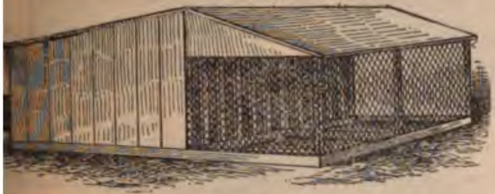


FIG. 18.—Chicken coop with inclosed and covered run.

**Nests.**—The simplest form of nest is a box placed upon the floor of the poultry house. With heavy fowls, which are to break their eggs in fighting away other hens that try to enter their ts when they are laying and thus acquire the habit of egg-eating, a re concealed or dark nest may necessary. (Figs. 10 and 11.)

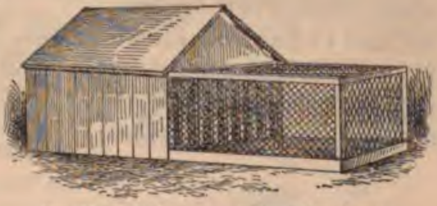


FIG. 19.—Chicken coop with inclosed run.

**Floor.**—One of the most trousome parts of a poultry house make satisfactory is the floor. ny use earth floors, but these often damp, especially in l weather, and then induce umatism, colds, roup, digest- disorders, and various other diseases. Some have put in cement rs, but have found these cold and also more or less damp. Probably a good cement floor, laid on broken stone and covered with a few inches of earth, would be satisfactory, if not too expensive. A board floor, six or eight inches above the earth, with good ventilation under it, is dry but too cold, except in the South. A double flooring, laid tightly with lding paper between, or a good single flooring covered with a few hes of dry earth, is probably the best. In all cases of board floors re should be sufficient space beneath for ventilation and to guard *inst the lodgment of rats.*

20.—Chicken coop with inclosed and covered run.

**Good plans.**—A good style of poultry house, with scratching room under it, is shown in fig. 12. In case more than one flock is to be kept, the plan shown in figs. 13 and 14 have been found satisfactory and may be multiplied to any extent by adding to the ends. With such houses there may be fenced runs at the back or front, or on both sides, so that the birds may be kept confined.

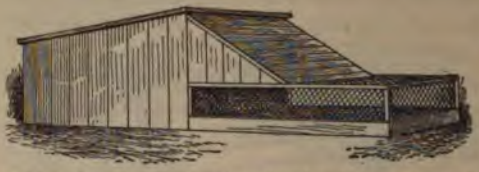


FIG. 21.—Chicken coop with inclosed and partly covered run.

### SPACE TO BE ALLOWED.

The amount of space to be allowed for each bird depends upon the size of the birds, whether a shed is attached to the house or whether the fowls have a free run of the open fields. For birds in confinement there should be from 6 to 15 square feet for each adult bird in case there is no shed attached to the house; and with a shed this space may be reduced about one-half. The yards should be large enough to allow exercise in the open air, and to furnish more grass than the birds will eat. This will vary from 60 to 150 square feet per adult bird. The open shed facing the south, where the birds can be induced to hunt for their food and take exercise in all seasons of the year, and where they can enjoy the pleasure of scratching and dusting themselves in the sunshine, even during the winter months, is of great assistance in maintaining the health and productiveness of the flock. The roosting space allowed should be 6 to 8 inches for the smaller breeds, 8 to 10 inches for the medium breeds, and 10 to 12 inches for the larger breeds.

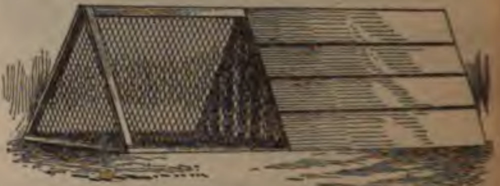


FIG. 22.—Chicken coop with inclosed run.

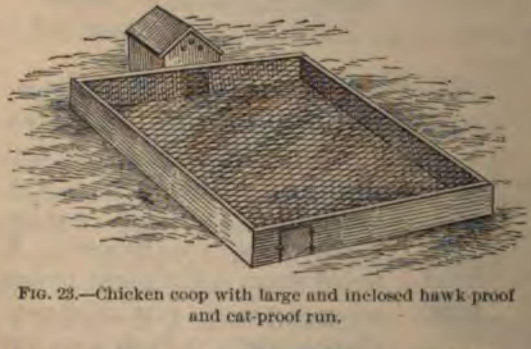


FIG. 23.—Chicken coop with large and inclosed hawk-proof and cat-proof run.

### VENTILATION.

Poultry houses should be well ventilated, but so arranged that drafts of air will not strike the birds. Windows and doors should be provided in such locations that the sun may shine into the building iderable part of the day. Sunshine is required both to keep the s dry and to destroy various forms of infection.

## POULTRY COOPS.

iberal supply of coops should be provided for the confinement of with broods of small chicks, and for those hens which insist upon

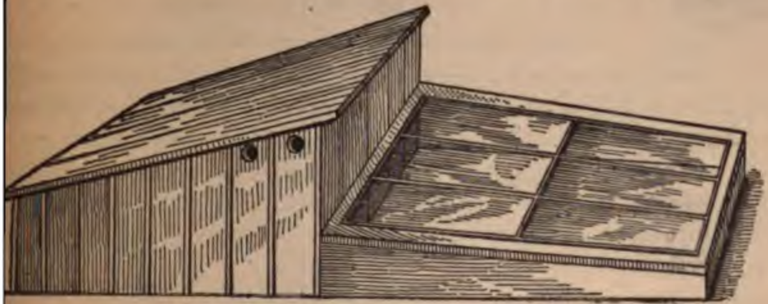


FIG. 24.—Coop with glass-covered run.

ng at inconvenient times. A few days in solitary retirement will lly break up the desire to sit, and the hen will soon after resume ng.

e common A-shaped coop is one of the most easily constructed and enient forms in use. The one disadvantage connected with it is lifficulty of removing the feeding and drinking vessels for clean- or of catching a bird in it without danger of some of the birds ping. To obviate this, one of the slats may be made to slide, as vn in fig. 15. The opening made by ng this slat is sufficient to admit the l and arm so that any part of the coop be reached without leaving an avenue cape unguarded. Other forms of coops he same purpose are illustrated by figs. 7, 18, 19, 20, 21, 22, and 23. For early hed chicks, which come out when the spheric temperature is so low as to be rious to them, a combination of coop glass-covered run, as shown in fig. 24, been found very useful.

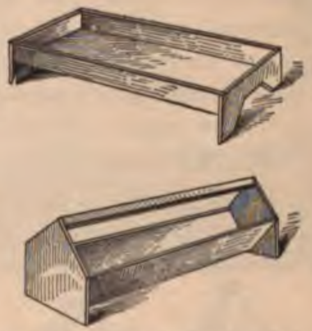


FIG. 25.—Two forms of feed troughs.

## FEED TROUGHS AND DRINKING FOUNTAINS.

vo forms of feed troughs are represented in fig. 25. For small ks the troughs must be very shallow, or for the first few days the may be placed upon a square piece of board. Numerous forms rinking fountains have been devised, some of which are repre- ed in figs. 26 and 27. A good fountain is easily made by cutting all aperture in a tin can, as shown in fig. 28, filling the can with r, covering with a shallow pan or vessel of any kind, and then inverting the whole. The shallow vessel will remain filled with as high as the top of the aperture until the can is exhausted. important that fresh pure water should always be accessible to and the drinking fountains should be cleaned an two or three times a day, if possible, and under no c stances less frequently than once a day.

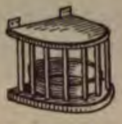


FIG. 26.—A form of drinking fountain.

### RANGING OF FOWLS.

Poultry may be raised with the greatest econo the large farms of the country, where there is unl range, an exhaustless supply of insects and worm an abundance of seeds and grains going to waste which p alone can utilize. Under such circumstances fowls take care of selves so well and are so energetic in seeking their food that th either forgotten and allowed to shift for themselves when they need attention and assistance, or they are regarded as a nu because they sometimes do a little damage. When fenced away from the gardens and flower beds, fowls do little damage and cause scarcely any annoyance on a farm. On the other hand, they do an immense amount of good in the protection of crops by the destruction of injurious insects, larvæ, and worms.

FIG. 27. of d fount

### COLONIES.

Sometimes it is advisable to divide the farm flock into coloni place these at different points upon the farm in order to secur tional range, to remove the birds temporarily to a distance fro tain crops, or for other purposes. In this case cheap, light, and handled colony houses (figs. 29, 30, and 31) may be construct placed where the fowls are desired to range. After being conf these houses a few nights the birds will adopt them as their tions and return to them.

### POULTRY IN COMBINATION WITH SPECIALTIES IN FAR

There are certain special lines of agricultural operations with poultry raising may be advantageously connected. In dairying is usually a large quantity of skim buttermilk which may be utilized to f a considerable part of the poultry There is also much food to be gathe the fowls about the stables, manure and pastures which would otherwise waste.

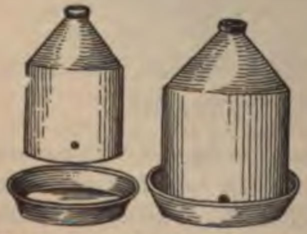


FIG. 28.—A drinking fountain made of a can.

### ADVANTAGES ON FRUIT FAR

Upon the fruit farm fowls are advantage. They keep down the pests, and they may have a free range the greater part of the without the possibility of doing any damage. Plum grower found poultry especially helpful in keeping down the curculio, and even apples have been considerably benefited. If small fruits are injured, they may, of course, be protected by confining the fowls for the limited season when the fruit is ripening. The waste fruits, either in winter or summer, are a welcome and valuable addition to the poultry ration.

### POULTRY AND THE MARKET GARDEN.

The market garden also furnishes a large amount of waste products which may be utilized for poultry feed. There is the waste lettuce, the small heads of cabbage, the unsold beets, carrots, and potatoes, the peas, and corn which can not be marketed for any reason, the waste of the small fruits, etc. If properly cared for, the hens will bring a steady and reliable income during the winter months. Dried clover and other green feed, roots, and tubers should be saved for them during the summer. These should be steamed and fed with the mash, or cabbages and beets may be fed raw. A catch crop of buckwheat or oats and peas will furnish much food at little expense. Bran, meat, meal, wheat screenings, and oats purchased for poultry will bring good returns in eggs and will also add materially to the fertilizer supply.

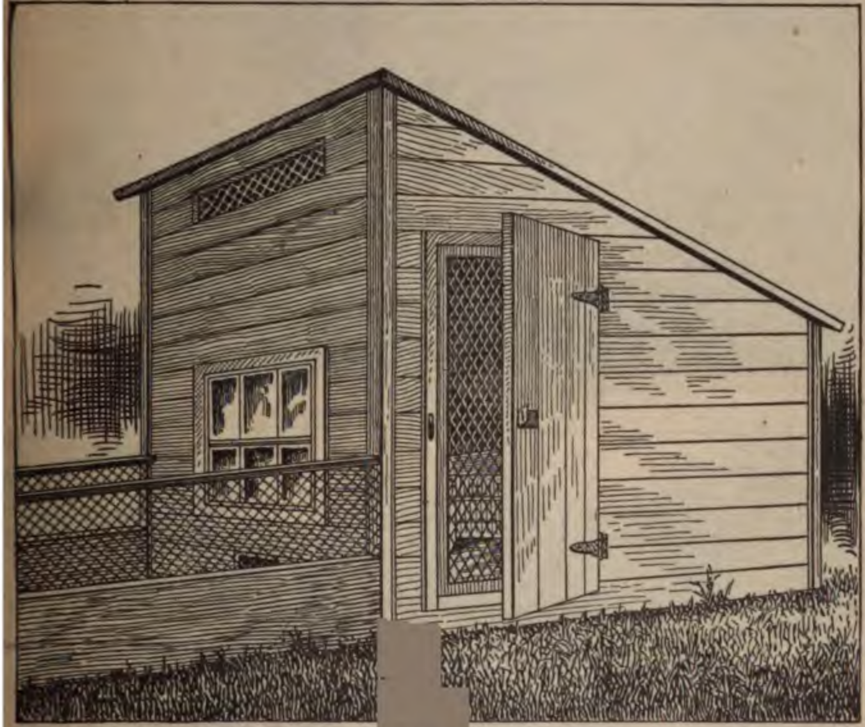


FIG. 29.—Colony house.

## OPPORTUNITIES AFFORDED BY THE DAIRY.

Dairymen who have town or city milk routes, and market gardeners who retail their produce, have exceptional opportunities for marketing fresh eggs and poultry at the highest prices. They become well acquainted with many of their customers by their daily visits, and they are looked upon as a direct channel of communication between the country and the city. They should by all means make the most of this advantage, for any class of agricultural producers who can reach the consumer without the intervention of the middleman is indeed fortunate.

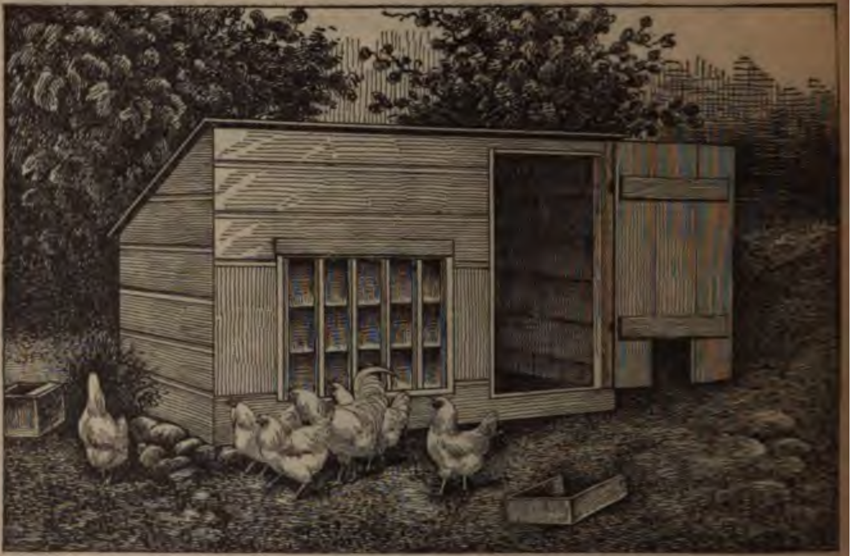


FIG. 30.—Colony house.

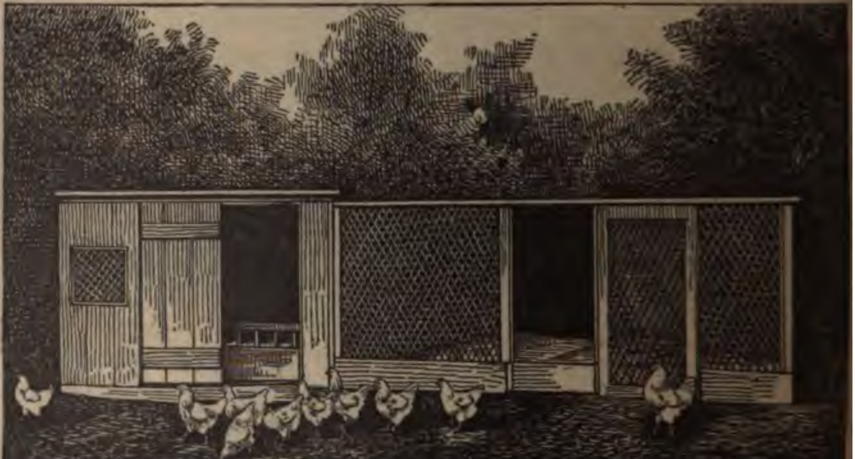


FIG. 31.—Colony house.

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. S. DEPARTMENT OF AGRICULTURE.

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FARMERS' BULLETIN No. 142.

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# IPLES OF NUTRITION AND NUTRITIVE VALUE OF FOOD.

[CORRECTED TO APRIL 5, 1906.]

BY

**W. O. ATWATER, Ph. D.,**

pecial Agent in Charge of Nutrition Investigations, Office of Experiment Stations.

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UNDER THE SUPERVISION OF THE OFFICE OF EXPERIMENT STATIONS
A. C. TRUE, Director.

LANE
STAN

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

# LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
*Washington, D. C., April 5, 1906.*

SIR: I have the honor to transmit herewith an article on Princip of Nutrition and Nutritive Value of Food, by Prof. W. O. Atwat special agent in charge of nutrition investigations, prepared in acco ance with instructions given by the Director of this Office. Fo number of years the Department has carried on studies regarding t kinds and amounts of foods consumed by persons of different occup tions and with different incomes, the composition of food, the relati cost of nutrients when furnished by different foods, and many mo technical questions. The present bulletin discusses the general pri ciples of nutrition, as well as a number of the more important phases the subject, with special reference to the results obtained in Depa ment investigations and the closely related work of the agricultu experiment stations. As the work has progressed the earlier ide have been modified, and the present bulletin is designed to suppleme and replace earlier Department publications by the author having similar scope. In preparing this bulletin Professor Atwater has h the assistance of Miss Helen W. Atwater.

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# INCIPLES OF NUTRITION AND NUTRITIVE VALUE OF FOOD.

## INTRODUCTION.

he problem of proper nutrition has always been of great impor-
ce, yet scientific study of this subject is comparatively recent. Food
stigations have been carried on in Europe for some three-quarters
century, and for a less time in the United States. In recent years
development of this subject has been very rapid; a large number of
stigations have been carried on under the auspices of this Depart-
t, the agricultural experiment stations, and various educational
itutions, and many facts of interest and importance have been
ned. It seems desirable, therefore, to summarize this informa-
, and, so far as possible, to interpret the results in such a way as
how their practical application.

onstant use has made us so familiar with our ordinary foods that
seldom realize how complicated they are; yet a thorough under-
ding of them takes us far, not only into chemistry, but into physics
physiology as well.

## CHEMICAL COMPOSITION OF THE BODY AND OF FOOD.

he chemical substances of which the body is composed are very
ilar to those of the foods which nourish it. They are made up of
same chemical elements, and hence the two may be discussed
ether. From fifteen to twenty elements are found, among the
st abundant of which are oxygen, hydrogen, carbon, nitrogen, cal-
m, phosphorus, and sulphur. The elements are so combined as to
m a great variety of compounds in both body and food. The most
ortant kinds of compounds in the body and in foods are protein,
s, carbohydrates, mineral matter, and water. The functions of
se compounds in the food, as explained in detail later in this bul-
n, are to build and repair the various tissues of the body and to
ply it with heat and muscular energy.

### WATER.

Water is one of the most abundant of these compounds. It forms over 60 per cent of the weight of the body of the average man, being a component part of all the tissues. It is thus an important constituent of our food, though it can not be burned, and hence does not yield energy to the body.

### MINERAL MATTER OR ASH.

Other food ingredients which yield little or no energy and are yet indispensable to the body are the mineral matters. They form only 5 or 6 per cent of the body by weight, and are found chiefly in the bones and teeth, but are present also in the other tissues and in solution in the various fluids. When food or body material is burned the mineral constituents remain as ash. Phosphate of lime, or calcium phosphate, is the mineral basis of bone. Numerous compounds of potassium, sodium, magnesium, and iron are found in the body and are necessary to life.

The remaining nutritive materials are organic compounds, so called because they occur principally in the organic, i. e., the animal and vegetable world. They all contain carbon, oxygen, and hydrogen, in varying proportions. Some also contain nitrogen, phosphorus, sulphur, or other elements. Those occurring in the body and in food are divided into three principal groups—protein, fats, and carbohydrates.

### PROTEIN.

This term includes the principal nitrogenous compounds. Protein is familiar to us in the lean and gristle of meat, the white of eggs, the gluten of wheat, etc. It forms about 18 per cent, by weight, of the body of the average man. Protein compounds may be subdivided into albuminoids, gelatinoids, and extractives. The first group, the albuminoids, include substances similar to the white of egg, the lean of meat (myosin), the curd of milk (casein), and the gluten of wheat. The second group, the gelatinoids,[a] occur principally in the connective tissues, such as the collagen of the tendons and skin and the ossein of bone.

The albuminoids and gelatinoids, classed together as proteids, are most important constituents of our food. They make the basis of bone, muscle, and other tissues, and are essential to the body structure. They are also used as fuel—that is, they are burned in the body to yield energy—and they are to some extent transformed into fat and stored in the body, but these are their less important uses. The pro-n compounds are most abundant in some of the animal foods, as n meat, though the cereals contain them in considerable, and peas d beans in large, proportions. The gelatinoids are less valuable an the albuminoids for nutriment.

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[a] The term albuminoids is often applied to what are here called gelatinoids; the term proteid is used in the same significance; indeed, there is great confusion in the use of these terms by different writers. The terminology here followed is that recommended by the American Association of Agricultural Colleges and Experiment Stations.

The third class, the so-called extractives, are included with the pro-in compounds because they contain nitrogen, but they differ greatly om the albuminoids and gelatinoids. They are the principal ingre-ients of meat extracts, beef tea, etc. They are believed to neither uild tissue nor furnish energy, but to act as stimulants and appetizers. he craving which some persons have for meat is perhaps due in part o a desire for these extractives. The nitrogenous compounds of otatoes and other vegetable foods contain more or less of so-called mids, like asparagin, which are analogous to the extractives of meat, nd like them can not build tissue, and hence have an inferior nutri-ive value.

## FATS.

Fats occur chiefly in animal foods, as meats, fish, butter, etc. They re also abundant in some vegetable products, such as olives and cot-on seed, from which they are expressed as oil, and occur in consider-ble quantities in some cereals, notably oatmeal and maize (whole ernel), and in various nuts. In our bodies and those of animals fats ccur in masses under the skin and in other localities, and in minute articles scattered through the various tissues. The amount of fat in he body varies greatly with food, exercise, age, and other conditions. hen more food is taken than is necessary for immediate use part of e surplus may be stored in the body. The protein and fat of food ay thus become body protein and body fat; sugar and starch of od are changed to fat in the body and stored as such. When the od supply is short this reserve material is drawn upon for supple-entary fuel. Fat forms about 15 per cent, by weight, of the body f an average man. Well-fed or overfed people with little muscular ercise often grow fat, but the tendency to fatness or leanness is ore or less a question of personal idiosyncrasy or some other little nderstood factor, and not decided by food and exercise alone.

## CARBOHYDRATES.

These include such compounds as starches, different kinds of sugar, nd the fiber of plants or cellulose. They are found chiefly in the egetable foods, like cereal grains and potatoes; milk, however, con-ins considerable amounts of milk sugar, which is a carbohydrate. he carbohydrates form only a very small proportion of the body ssues—less than 1 per cent. Starches and sugars, which are very bundant in ordinary food materials, are important food ingredients, ecause they form an abundant source of energy and are easily igested. They may be and often are transformed into fat in the body.

### REFUSE.

Food, as we buy it at the market or even as it is served on the table, contains more or less of materials which we can not or do not eat, and which would have little or no nutritive value if we did eat them; such, for instance, as the bones of meat and fish, the shells of eggs, and the skins and seeds of fruits and vegetables. In discussing the chemical composition of foods such portions are usually counted as refuse, but they make an important item when we consider the actual cost of the nutrients of food. The materials grouped together as refuse contain, in part, the same ingredients as the edible portion, though usually in very different proportions. Thus bones are largely mineral matter, with some fat and protein; eggshells are almost entirely mineral matter; bran of wheat has a high content of fiber or woody material. Generally speaking, vegetable refuse is characterized by a high content of these latter constituents. In some cases material which is edible is classed as refuse because the flavor is objectionable. Thus peach and plum pits are too highly flavored to be agreeable if eaten in quantity, and are commonly thought to be actually injurious.

## FOOD AS BUILDING MATERIAL AND FUEL.

### THE BODY AS A MACHINE.

Blood and muscle, bone and tendon, brain and nerve—all the organs and tissues of the body—are built from the nutritive ingredients of food. With every motion of the body and with the exercise of feeling and thought as well, material is consumed and must be resupplied by food. In a sense, the body is a superior machine. Like other machines, it requires material to build up its several parts, to repair them as they are worn out, and to serve as fuel. In some ways it uses this material like a machine; in others it does not. The steam engine gets its power from fuel; the body does the same. In the one case coal or wood, in the other food, is the fuel. In both cases the energy which is latent in the fuel—the potential energy, as it is called in scientific language—is transformed into power and heat.

From the time foods are taken into the body until they are digested, absorbed, utilized, and finally converted largely into the carbon dioxid and water vapor of the breath and the nitrogenous and other excretory products of the urine and feces, they undergo great chemical changes, very many of which liberate heat as a result of oxidation or some closely related process. It is through these complex chemical processes that the body derives the energy for internal and external muscular work. Heat is evolved by such chemical changes and also results from the muscular work of the body, and there is reason to believe that within wide limits the heat thus produced is sufficient for maintaining body temperature. The amount of heat produced in the body nust, of course, vary with the amount of food eaten, the work done, ind other circumstances. However, the body is such a perfect piece of mechanism that the loss of heat by radiation, etc., is so adjusted to heat production that body temperature remains fairly constant.

One important difference between the human machine and the steam engine is that the former is self-building, self-repairing, and self-regulating. Another is that the material of which the engine is built is very different from that which it uses for fuel, but part of the material which serves the body as a source of energy also builds it up and keeps it in repair. Furthermore, the body can use its own substance for this purpose. This the steam engine can not do. The steam engine and the body are alike in that both convert the fuel into mechanical power and heat. They differ in that the body uses the same material for fuel as for building and also consumes its own material for fuel. In the use of its source of power the body is much more economical than any engine.

But the body is more than a machine. It has not simply organs to build and keep in repair and supply with energy; it has a nervous organization; it has sensibilities; and there are the higher intellectual and spiritual faculties. The right exercise of these depends upon the right nutrition of the body.

The chief uses of food, then, are two: (1) To form the material of the body and repair its wastes, and (2) to furnish muscular and other power for the work the body has to do and yield heat to keep the body warm. In forming the tissues and the fluids of the body the food serves for building and repair. In yielding power and heat it serves as fuel.

If more food is eaten than is needed, more or less of the surplus may be and sometimes is stored in the body, chiefly in the form of fat. The fat in the body forms a sort of reserve supply of fuel and is utilized in the place of food. When the work is hard or the food supply is low the body draws upon this store of fat and grows lean.

## PROTEIN AS BUILDING MATERIAL.

The principal tissue formers are the protein compounds, especially the albuminoids. These make the framework of the body. They build up and repair the nitrogeneous materials, as the muscles and tendons, and supply the albuminoids of the blood, milk, and other fluids.

The albuminoids of food are transformed into the albuminoids and gelatinoids of the body. Muscle, tendon and cartilage, bone and skin, the corpuscles of the blood, and the casein of milk are made of the albuminoids of food. The albuminoids are sometimes called "flesh formers" or "muscle formers," because the lean flesh, the muscle, is made from them, though the term is inadequate, as it leaves out of account the energy-furnishing function of protein. The gelatinoi food, such as the finer particles of tendon and the gelatin —

dissolved out of bone and meat in soup, though somewhat similar to the albuminoids in composition, are not believed to be tissue formers; but they are valuable in protecting the albuminoids from consumption. That is, when the food contains gelatinoids in abundance less of albuminoids is used.

The proteids can be so changed in the body as to yield fats and carbohydrates, and such changes actually occur to some extent. In this and other ways they supply the body with fuel.

### PROTEIN AS FUEL FOR THE BODY.

The protein compounds are not only used for building and repairing tissue, but are also burned directly in the body like the carbohydrates, and thus render important service as fuel. A dog can live on lean meat. He can convert its material into muscle and its energy into heat and muscular power. Man can do the same; but such a one-sided diet would not be best for the dog and it would be still worse for man. The natural food for carniverous animals, like the dog, supplies fats and some carbohydrates, and that for omnivorous animals, like man, furnishes fats and carbohydrates in liberal amounts along with protein. Herbivorous animals, like horses, cattle, and sheep, naturally require large proportions of carbohydrates.

### FATS AND CARBOHYDRATES AS FUEL.

Fats and carbohydrates are the chief fuel ingredients of food. Sugar and the starch of bread and potatoes are burned in the body to yield heat and power. The fats, such as the fat of meat and butter, serve the same purpose, only they are a more concentrated fuel than the carbohydrates.

The body can also transform carbohydrates of food into fat. This fat, and with it that stored from the food, is kept in the body as reserve fuel in the most concentrated form.

The different nutrients can to a greater or less extent do one another's work. If the body has not enough of one kind of fuel it can use another. But, while protein can be burned in the place of fats and carbohydrates, neither of the latter can take the place of the albuminoids in building and repairing the tissues. At the same time the gelatinoids, fats, and carbohydrates, by being consumed themselves, protect the albuminoids from consumption.

### VALUE OF FOOD FOR SUPPLYING ENERGY.

Heat and muscular power are forms of force or energy. The energy latent in the food is developed as the food is consumed in the body. The process is more or less akin to that which takes place when coal is burned in the furnace of the locomotive. For the burning of the food in the body or the coal in the furnace, air is used to supply oxygen.

en the fuel is oxidized, be it meat or wood, bread or coal, the latent rgy becomes active, or, in technical language, the potential energy omes kinetic; it is transformed into power and heat. As various ds of coal differ in the amount of heat given off per ton, so various ds of food and food ingredients give off different amounts of energy; t is, have different values as fuel in the body.

### HEAT OF COMBUSTION.

he processes of oxidation of material and transformation of energy he body are less simple than in the engine and less clearly underod. Late research, however, has given us ways of measuring the rgy latent in coal, wood, and in food materials as well. This is st generally done in the chemical laboratory by an apparatus called bomb calorimeter. The amount of heat given off in the oxidation given quantity of any material is called its "heat of combustion," is taken as a measure of its latent or potential energy. The unit monly used is the calorie, the amount of heat which would raise temperature of 1 kilogram of water 1° C., or, what is nearly the e thing, 1 pound of water 4° F. Instead of this unit of heat a unit nechanical energy may be used—for instance, the foot-ton, which resents the force required to raise 1 ton 1 foot. One calorie is equal very nearly 1.54 foot-tons; that is to say, 1 calorie of heat, when nsformed into mechanical power, would suffice to lift 1 ton 1.54 feet.

### THE CONSERVATION OF ENERGY IN THE BODY.

he amounts of energy transformed in the body when food and its n material are burned within it are measured with the respiration orimeter referred to on page 13. It is well known that the food is not npletely oxidized in the body. These experiments have shown that material which is oxidized yields the same amount of energy as it uld if burned with oxygen outside the body, e. g., in the bomb orimeter. The experiments show also that when a man does no scular work (save, of course, the internal work of respiration, circuon, etc.), all the energy leaves his body as heat; but when he does scular work, as in lifting weights or driving a bicycle, part of the rgy appears in the external work thus done, and the rest is given from the body as heat. The most interesting result of all is that energy given off from the body as heat when the man is at rest, s heat and mechanical work together when he is working, exactly als the latent energy of the material burned in the body. This is accordance with the law of the conservation of energy. It thus ears that the body actually obeys, as we should expect it to obey, great law which dominates the physical universe.

## FUEL VALUE.

We may make practical application of this principle of the conservation of energy in the body in measuring the actual value of food a fuel to the body, i. e., its "fuel value," by use of the bomb and respiration calorimeters. To do this we have to take into account the chemical composition of the food, the proportions of the nutrients actually digested and oxidized in the body, and the proportion of the whol latent energy of each which becomes active and useful to the body fo warmth and work. Taking our common food materials as they ar used in ordinary diet, the following general estimate has been mad for the energy furnished to the body by 1 gram or 1 pound of each o the classes of nutrients:[a]

Protein, fuel value, 4 calories per gram, or 1,820 calories per pound.
Fats, fuel value, 8.9 calories per gram, or 4,040 calories per pound.
Carbohydrates, fuel value, 4 calories per gram, or 1,820 calories per pound.

It will be seen that when we compare the nutrients in respect to their fuel value, their capacities for yielding heat and mechanical power, a pound of protein of lean meat or albumen of egg is just about equivalent to a pound of sugar or starch, and a little over 2 pounds of either would be required to equal a pound of the fat of meat or butter or of body fat.

The fuel value of food obviously depends upon the amounts of actual nutrients, and especially upon the amount of fat it contains. Thus a pound of wheat flour, which consists largely of starch, has an averag fuel value of about 1,625 calories, and a pound of butter, which is mostly fat, about 3,410 calories. These are only about one-eighth water. Whole milk, which is seven-eighths water, has an averag fuel value of 310 calories per pound; cream, which has more fat and less water, 865 calories, and skim milk, which is whole milk after the cream has been removed, 165 calories.

This high fuel value of fat explains the economy of nature in storing fat in the body for use in case of need. Fat is the most concentrated form of body fuel.

We have been considering food as a source of heat and muscular power. There is no doubt that intellectual activity, also, is somehow dependent upon the consumption of material which the brain has obtained from the food; but just what substances are consumed to produce brain and nerve force, and how much of each is required for a given quantity of intellectual labor, are questions which the physiological chemist has not yet answered.

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[a] These estimates are based upon the latest and most reliable research and take in account only the material which is digested and oxidized so that its energy is act available to the body. Earlier estimates, based on less accurate data and not maki allowance for the amounts of fats and carbohydrates which escape oxidation in the bod give 4.1 calories per gram, or 1,860 calories per pound, for protein and carbohydrates a 9.3 calories per gram, or 4,220 for fats, figures which have come into common use.

## W THE FUNCTIONS AND NUTRITIVE VALUE OF FOOD ARE LEARNED.

The principles above explained are based upon a great deal of erimenting and observation. The experimenting is of many ds, but of especial importance is the work with the respiration aratus and respiration calorimeter.

Various forms of respiration apparatus have been devised within last fifty years. Among the most important are those invented Pettenkofer and Voit in Munich. They consist of metal-walled mbers large enough for the subject (sometimes a man, sometimes og, sheep, or other animal) to live in comfortably for several days, are furnished with devices for pumping air through and measur- and analyzing it as it enters and leaves the chamber. With h an apparatus it is possible not only to measure all the food and reta, but also the materials given off from the lungs in the breath, to make accurate determinations of the matter entering and leav- the body.

A still more elaborate apparatus, by which not only all the matter sing in and out of the body may be measured, but also all the heat en off from it, is called a respiration calorimeter—that is, a machine measuring both the respiratory products and the heat given off by body. It is like the respiration apparatus, except that it is fur- hed with devices for measuring temperatures. Several have been lt in Europe within the last twenty years, among the most success- being those by Rubner and Rosenthal.[a] Investigations in coop- ation with the United States Department of Agriculture are now ing carried on in one recently built by the author and Professor osa at Wesleyan University.[b] Its main feature is a copper-walled amber 7 feet long, 4 feet wide, and 6 feet 4 inches high. This is ted with devices for maintaining and measuring a ventilating cur- nt of air, for sampling and analyzing this air, for removing and easuring the heat given off within the chamber, and for passing food d other articles in and out. It is furnished with a folding bed, air, and table, with scales and with appliances for muscular work, d has telephone connection with the outside. Here the subject ays for a period of from three to twelve days, during which time care- l analyses and measurements are made of all material which enters e body in the food and of that which leaves it in the breath and creta. Record is also kept of the energy given off from the body as at and muscular work. The differences between the material taken to and that given off from the body is called the balance of matter, d shows whether the body is gaining or losing material. The difference between the energy of the food taken and that of the excreta and the energy given off from the body as heat and muscular work, is the balance of energy, and if correctly estimated should equal the energy of the body material gained or lost.

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[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 21, p. 133.

[b] U. S. Dept. Agr., Office of Experiment Stations Bul. 63.

With such apparatus it is possible to learn what effect different conditions of nourishment will have on the human body. In one experiment, for instance, the subject might be kept quite at rest, and in the next do a certain amount of muscular or mental work, with the same diet as before. Then by comparing the results of the two the use which the body makes of its food under the different conditions could be determined. Or the diet may be slightly changed in one experiment and the effect of this on the balance of matter and energy observed. Such methods and apparatus are very costly in time and money, but the results are proportionately more valuable than those from simpler experiments.

## FOOD AND FOOD ECONOMY.

What has thus far been said about the ingredients of food and the ways they are used in the body may be briefly summarized in the following schematic manner:

*Nutritive ingredients (or nutrients) of food.*

- Food as purchased contains—
  - Edible portion.................... e. g., flesh of meat, yolk and white of eggs, wheat, flour, etc.
    - Water.
    - Nutrients...
      - Protein.
      - Fats.
      - Carbohydrates.
      - Mineral matters.
  - Refuse. e. g., bones, entrails, shells, bran, etc.

*Uses of nutrients in the body.*

| | | |
|---|---|---|
| Protein.................... e. g., white (albumen) of eggs, curd (casein) of milk, lean meat, gluten of wheat, etc. | Forms tissue................. | All serve as fuel to yield energy in the forms of heat and muscular power. |
| Fats...................... e. g., fat of meat, butter, olive oil, oils of corn and wheat, etc. | Are stored as fat............. | |
| Carbohydrates.............. e. g., sugar, starch, etc. | Are transformed into fat........ | |
| Mineral matters (ash).......... e. g., phosphates of lime, potash, soda, etc. | Share in forming bone, assist in digestion, etc. | |

The views thus presented lead to the following definitions: (1) Food is that which, taken into the body, builds tissues or yields energy;

(2) the most healthful food is that which is best fitted to the needs of the user; (3) the cheapest food is that which furnishes the largest amount of nutriment at the least cost; and (4) the best food is that which is both most healthful and cheapest.

We have, then, to consider the kinds and amounts of nutrients in different food materials, their digestibility, the kinds and amounts needed for nourishment by persons under different conditions of rest and work, and the nutritive value of different food products as compared with their cost.

## COMPOSITION OF COMMON FOOD MATERIALS.

The value of food for nutriment depends mainly upon its composition and digestibility. The composition of foods is determined by chemical analysis. The first effective impulse to the systematic study of the chemistry of foods was given by Liebig somewhat over 50 years ago, but nearly all of our definite knowledge of the chemical composition of food materials has accumulated within comparatively a few years past.

Until about the year 1880 those who wished to know about the chemical composition of food materials were compelled to depend upon analyses of European products, and most of those analyses had been made in German laboratories. During the last two decades, however, American investigations have accumulated until at the present time the results of over 4,000 analyses of food materials from different parts of the United States are available. A large proportion of these analyses have been made during the last few years in connection with nutrition investigations under the auspices of the Department of Agriculture.

The methods of chemical analysis of foods are now so nearly uniform throughout the world that the analyses reported from different countries furnish a reliable means of comparing the composition of the food products of different parts of the world.

Table I shows the average composition of ordinary American food materials as calculated from the analyses now available.[a] The value of food as influenced by digestibility is discussed later. (See Table II, p. 27.)

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[a] Condensed from U. S. Dept. Agr., Office of Experiment Stations Bul. 28, revised.

TABLE I.—*Average composition of common American food products.*

| Food materials (as purchased). | Refuse. | Water. | Protein. | Fat. | Carbohydrates. | Ash. | Fuel value per pound. |
|---|---|---|---|---|---|---|---|
| ANIMAL FOOD. | | | | | | | |
| Beef, fresh: | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | Calories. |
| Chuck ribs | 16.3 | 52.6 | 15.5 | 15.0 | ........ | 0.8 | [illegible] |
| Flank | 10.2 | 54.0 | 17.0 | 19.0 | ........ | .7 | 1,0 |
| Loin | 13.3 | 52.5 | 16.1 | 17.5 | ........ | .9 | 1,0 |
| Porterhouse steak | 12.7 | 52.4 | 19.1 | 17.9 | ........ | .8 | 1,10 |
| Sirloin steak | 12.8 | 54.0 | 16.5 | 16.1 | ........ | .9 | 97 |
| Neck | 27.6 | 45.9 | 14.5 | 11.9 | ........ | .7 | 1,1 |
| Ribs | 20.8 | 43.8 | 13.9 | 21.2 | ........ | .7 | 1,1 |
| Rib rolls | ........ | 63.9 | 19.3 | 16.7 | ........ | .9 | 1,0 |
| Round | 7.2 | 60.7 | 19.0 | 12.8 | ........ | 1.0 | [illegible] |
| Rump | 20.7 | 45.0 | 13.8 | 20.2 | ........ | .7 | 1,0 |
| Shank, fore | 36.9 | 42.9 | 12.8 | 7.3 | ........ | .6 | 54 |
| Shoulder and clod | 16.4 | 56.8 | 16.4 | 9.8 | ........ | .9 | 72 |
| Fore quarter | 18.7 | 49.1 | 14.5 | 17.5 | ........ | .7 | 9 |
| Hind quarter | 15.7 | 50.4 | 15.4 | 18.3 | ........ | .7 | 1,04 |
| Beef, corned, canned, pickled, and dried: | | | | | | | |
| Corned beef | 8.4 | 49.2 | 14.3 | 23.8 | ........ | 4.6 | 1,2 |
| Tongue, pickled | 6.0 | 58.9 | 11.9 | 19.2 | ........ | 4.3 | 1,1 |
| Dried, salted, and smoked | 4.7 | 53.7 | 26.4 | 6.9 | ........ | 8.9 | [illegible] |
| Canned boiled beef | ........ | 51.8 | 25.5 | 22.5 | ........ | 1.3 | [illegible] |
| Canned corned beef | ........ | 51.8 | 26.3 | 18.7 | ........ | 4.0 | 1,2 |
| Veal: | | | | | | | |
| Breast | 21.3 | 52.0 | 15.4 | 11.0 | ........ | .8 | [illegible] |
| Leg | 14.2 | 60.1 | 15.5 | 7.9 | ........ | .9 | [illegible] |
| Leg cutlets | 3.4 | 68.3 | 20.1 | 7.5 | ........ | 1.0 | [illegible] |
| Fore quarter | 24.5 | 54.2 | 15.1 | 6.0 | ........ | .7 | [illegible] |
| Hind quarter | 20.7 | 56.2 | 16.2 | 6.6 | ........ | .8 | [illegible] |
| Mutton: | | | | | | | |
| Flank | 9.9 | 39.0 | 13.8 | 36.9 | ........ | .6 | [illegible] |
| Leg, hind | 18.4 | 51.2 | 15.1 | 14.7 | ........ | .8 | [illegible] |
| Loin chops | 16.0 | 42.0 | 13.5 | 28.3 | ........ | .7 | 1,6 |
| Fore quarter | 21.2 | 41.6 | 12.3 | 24.5 | ........ | .7 | 1,2 |
| Hind quarter, without tallow | 17.2 | 45.4 | 13.8 | 23.2 | ........ | .7 | [illegible] |
| Lamb: | | | | | | | |
| Breast | 19.1 | 45.5 | 15.4 | 19.1 | ........ | .8 | 1,1 |
| Leg, hind | 17.4 | 52.9 | 15.9 | 13.6 | ........ | .9 | [illegible] |
| Pork, fresh: | | | | | | | |
| Ham | 10.7 | 48.0 | 13.5 | 25.9 | ........ | .8 | 1,22 |
| Loin chops | 19.7 | 41.8 | 13.4 | 24.2 | ........ | .8 | 1,24 |
| Shoulder | 12.4 | 44.9 | 12.0 | 29.8 | ........ | .7 | 1,45 |
| Tenderloin | ...... | 66.5 | 18.9 | 13.0 | ........ | 1.0 | [illegible] |
| Pork, salted, cured, and pickled: | | | | | | | |
| Ham, smoked | 13.6 | 34.8 | 14.2 | 33.4 | ........ | 4.2 | 1,63 |
| Shoulder, smoked | 18.2 | 36.8 | 13.0 | 26.6 | ........ | 5.5 | 1,33 |
| Salt pork | ........ | 7.9 | 1.9 | 86.2 | ........ | 3.9 | 3,55 |
| Bacon, smoked | 7.7 | 17.4 | 9.1 | 62.2 | ........ | 4.1 | 2,71 |
| Sausage: | | | | | | | |
| Bologna | 3.3 | 55.2 | 18.2 | 19.7 | ........ | 3.8 | 1,15 |
| Pork | ........ | 39.8 | 13.0 | 44.2 | 1.1 | 2.2 | 2,07 |
| Frankfort | ........ | 57.2 | 19.6 | 18.6 | 1.1 | 3.4 | 1,15 |
| Soups: | | | | | | | |
| Celery, cream of | ........ | 88.6 | 2.1 | 2.8 | 5.0 | 1.5 | 235 |
| Beef | ........ | 92.9 | 4.4 | .4 | 1.1 | 1.2 | 120 |
| Meat stew | ........ | 84.5 | 4.6 | 4.3 | 5.5 | 1.1 | 365 |
| Tomato | ........ | 90.0 | 1.8 | 1.1 | 5.6 | 1.5 | 185 |
| Poultry: | | | | | | | |
| Chicken, broilers | 41.6 | 43.7 | 12.8 | 1.4 | ........ | .7 | 305 |
| Fowls | 25.9 | 47.1 | 13.7 | 12.3 | ........ | .7 | 765 |
| Goose | 17.6 | 38.5 | 13.4 | 29.8 | ........ | .7 | 1,47 |
| Turkey | 22.7 | 42.4 | 16.1 | 18.4 | ........ | .8 | 1,06 |
| Fish: | | | | | | | |
| Cod, dressed | 29.9 | 58.5 | 11.1 | .2 | ........ | .8 | 220 |
| Halibut, steaks or sections | 17.7 | 61.9 | 15.3 | 4.4 | ........ | .9 | 475 |
| Mackerel, whole | 44.7 | 40.4 | 10.2 | 4.2 | ........ | .7 | 370 |
| Perch, yellow, dressed | 35.1 | 50.7 | 12.8 | .7 | ........ | .9 | 275 |
| Shad, whole | 50.1 | 35.2 | 9.4 | 4.8 | ........ | .7 | 380 |
| Shad, roe | ........ | 71.2 | 20.9 | 3.8 | 2.6 | 1.5 | 600 |
| Fish, preserved: | | | | | | | |
| Cod, salt | 24.9 | 40.2 | 16.0 | .4 | ........ | 18.5 | 325 |
| Herring, smoked | 44.4 | 19.2 | 20.5 | 8.8 | ........ | 7.4 | 755 |
| Fish, canned: | | | | | | | |
| Salmon | ........ | 63.5 | 21.8 | 12.1 | ........ | 2.6 | 915 |
| Sardines | ᵃ5.0 | 53.6 | 23.7 | 12.1 | ........ | 5.3 | 950 |
| Shellfish: | | | | | | | |
| Oysters, "solids" | ........ | 88.3 | 6.0 | 1.3 | 3.3 | 1.1 | 225 |
| Clams | ........ | 80.8 | 10.6 | 1.1 | 5.2 | 2.3 | 340 |
| Crabs | 52.4 | 36.7 | 7.9 | .9 | .6 | 1.5 | 200 |
| Lobsters | 61.7 | 30.7 | 5.9 | .7 | .2 | .8 | 145 |

[a] Refuse, oil.

TABLE I.—*Average composition of common American food products*—Continued.

| Food materials (as purchased). | Refuse. | Water. | Protein. | Fat. | Carbohydrates. | Ash. | Fuel value per pound. |
|---|---|---|---|---|---|---|---|
| ANIMAL FOOD—continued. | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Calories.* |
| Eggs: Hens' eggs | [a]11.2 | 65.5 | 13.1 | 9.3 | | 0.9 | 635 |
| Dairy products, etc.: | | | | | | | |
| Butter | | 11.0 | 1.0 | 85.0 | | 3.0 | 3,410 |
| Whole milk | | 87.0 | 3.3 | 4.0 | 5.0 | .7 | 310 |
| Skim milk | | 90.5 | 3.4 | .3 | 5.1 | .7 | 165 |
| Buttermilk | | 91.0 | 3.0 | .5 | 4.8 | .7 | 160 |
| Condensed milk | | 26.9 | 8.8 | 8.3 | 54.1 | 1.9 | 1,430 |
| Cream | | 74.0 | 2.5 | 18.5 | 4.5 | .5 | 865 |
| Cheese, Cheddar | | 27.4 | 27.7 | 36.8 | 4.1 | 4.0 | 2,075 |
| Cheese, full cream | | 34.2 | 25.9 | 33.7 | 2.4 | 3.8 | 1,885 |
| VEGETABLE FOOD. | | | | | | | |
| Flour, meal, etc.: | | | | | | | |
| Entire-wheat flour | | 11.4 | 13.8 | 1.9 | 71.9 | 1.0 | 1,650 |
| Graham flour | | 11.3 | 13.3 | 2.2 | 71.4 | 1.8 | 1,645 |
| Wheat flour, patent roller process— | | | | | | | |
| High-grade and medium | | 12.0 | 11.4 | 1.0 | 75.1 | .5 | 1,635 |
| Low grade | | 12.0 | 14.0 | 1.9 | 71.2 | .9 | 1,640 |
| Macaroni, vermicelli, etc | | 10.3 | 13.4 | .9 | 74.1 | 1.3 | 1,645 |
| Wheat breakfast food | | 9.6 | 12.1 | 1.8 | 75.2 | 1.3 | 1,680 |
| Buckwheat flour | | 13.6 | 6.4 | 1.2 | 77.9 | .9 | 1,605 |
| Rye flour | | 12.9 | 6.8 | .9 | 78.7 | .7 | 1,620 |
| Corn meal | | 12.5 | 9.2 | 1.9 | 75.4 | 1.0 | 1,635 |
| Oat breakfast food | | 7.7 | 16.7 | 7.3 | 66.2 | 2.1 | 1,800 |
| Rice | | 12.3 | 8.0 | .3 | 79.0 | .4 | 1,620 |
| Tapioca | | 11.4 | .4 | .1 | 88.0 | .1 | 1,650 |
| Starch | | | | | 90.0 | | 1,675 |
| Bread, pastry, etc.: | | | | | | | |
| White bread | | 35.3 | 9.2 | 1.3 | 53.1 | 1.1 | 1,200 |
| Brown bread | | 43.6 | 5.4 | 1.8 | 47.1 | 2.1 | 1,040 |
| Graham bread | | 35.7 | 8.9 | 1.8 | 52.1 | 1.5 | 1,195 |
| Whole-wheat bread | | 38.4 | 9.7 | .9 | 49.7 | 1.3 | 1,130 |
| Rye bread | | 35.7 | 9.0 | .6 | 53.2 | 1.5 | 1,170 |
| Cake | | 19.9 | 6.3 | 9.0 | 63.3 | 1.5 | 1,630 |
| Cream crackers | | 6.8 | 9.7 | 12.1 | 69.7 | 1.7 | 1,925 |
| Oyster crackers | | 4.8 | 11.3 | 10.5 | 70.5 | 2.9 | 1,910 |
| Soda crackers | | 5.9 | 9.8 | 9.1 | 73.1 | 2.1 | 1,875 |
| Sugars, etc.: | | | | | | | |
| Molasses | | | | | 70.0 | | 1,225 |
| Candy[b] | | | | | 96.0 | | 1,680 |
| Honey | | | | | 81.0 | | 1,420 |
| Sugar, granulated | | | | | 100.0 | | 1,750 |
| Maple sirup | | | | | 71.4 | | 1,250 |
| Vegetables:[c] | | | | | | | |
| Beans, dried | | 12.6 | 22.5 | 1.8 | 59.6 | 3.5 | 1,520 |
| Beans, Lima, shelled | | 68.5 | 7.1 | .7 | 22.0 | 1.7 | 540 |
| Beans, string | 7.0 | 83.0 | 2.1 | .3 | 6.9 | .7 | 170 |
| Beets | 20.0 | 70.0 | 1.3 | .1 | 7.7 | .9 | 160 |
| Cabbage | 15.0 | 77.7 | 1.4 | .2 | 4.8 | .9 | 115 |
| Celery | 20.0 | 75.6 | .9 | .1 | 2.6 | .8 | 65 |
| Corn, green (sweet), edible portion | | 75.4 | 3.1 | 1.1 | 19.7 | .7 | 440 |
| Cucumbers | 15.0 | 81.1 | .7 | .2 | 2.6 | .4 | 65 |
| Lettuce | 15.0 | 80.5 | 1.0 | .2 | 2.5 | .8 | 65 |
| Mushrooms | | 88.1 | 3.5 | .4 | 6.8 | 1.2 | 185 |
| Onions | 10.0 | 78.9 | 1.4 | .3 | 8.9 | .5 | 190 |
| Parsnips | 20.0 | 66.4 | 1.3 | .4 | 10.8 | 1.1 | 230 |
| Peas (*Pisum sativum*), dried | | 9.5 | 24.6 | 1.0 | 62.0 | 2.9 | 1,565 |
| Peas (*Pisum sativum*), shelled | | 74.6 | 7.0 | .5 | 16.9 | 1.0 | 440 |
| Cowpeas, dried | | 13.0 | 21.4 | 1.4 | 60.8 | 3.4 | 1,505 |
| Potatoes | 20.0 | 62.6 | 1.8 | .1 | 14.7 | .8 | 295 |
| Rhubarb | 40.0 | 56.6 | .4 | .4 | 2.2 | .4 | 60 |
| Sweet potatoes | 20.0 | 55.2 | 1.4 | .6 | 21.9 | .9 | 440 |
| Spinach | | 92.3 | 2.1 | .3 | 3.2 | 2.1 | 95 |
| Squash | 50.0 | 44.2 | .7 | .2 | 4.5 | .4 | 100 |
| Tomatoes | | 94.3 | .9 | .4 | 3.9 | .5 | 100 |
| Turnips | 30.0 | 62.7 | .9 | .1 | 5.7 | .6 | 120 |
| Vegetables, canned: | | | | | | | |
| Baked beans | | 68.9 | 6.9 | 2.5 | 19.6 | 2.1 | 555 |
| Peas (*Pisum sativum*), green | | 85.3 | 3.6 | .2 | 9.8 | 1.1 | 235 |
| Corn, green | | 76.1 | 2.8 | 1.2 | 19.0 | .9 | 430 |
| Succotash | | 75.9 | 3.6 | 1.0 | 18.6 | .9 | 425 |
| Tomatoes | | 94.0 | 1.2 | .2 | 4.0 | .6 | 95 |

[a] Refuse, shell.

[b] Plain confectionery not containing nuts, fruit, or chocolate.

[c] Such vegetables as potatoes, squash, beets, etc., have a certain amount of inedible material, skin seeds, etc. The amount varies with the method of preparing the vegetables, and can not be rately estimated. The figures given for refuse of vegetables, fruits, etc., are assumed approximately the amount of refuse in these foods as ordinarily prepared.

TABLE I.—*Average composition of common American food products*—Continued.

| Food materials (as purchased). | Refuse. | Water. | Protein. | Fat. | Carbohydrates. | Ash. | Fuel value per pound |
|---|---|---|---|---|---|---|---|
| VEGETABLE FOOD—continued. | | | | | | | |
| Fruits, berries, etc., fresh: [a] | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Calories.* |
| Apples | 25.0 | 63.3 | 0.3 | 0.3 | 10.8 | 0.3 | 190 |
| Bananas | 35.0 | 48.9 | .8 | .4 | 14.3 | .6 | 260 |
| Grapes | 25.0 | 58.0 | 1.0 | 1.2 | 14.4 | .4 | 295 |
| Lemons | 30.0 | 62.5 | .7 | .5 | 5.9 | .4 | 125 |
| Muskmelons | 50.0 | 44.8 | .3 | ........ | 4.6 | .3 | 80 |
| Oranges | 27.0 | 63.4 | .6 | .1 | 8.5 | .4 | 150 |
| Pears | 10.0 | 76.0 | .5 | .4 | 12.7 | .4 | 230 |
| Persimmons, edible portion | ........ | 66.1 | .8 | .7 | 31.5 | .9 | 550 |
| Raspberries | ........ | 85.8 | 1.0 | ........ | 12.6 | .6 | 220 |
| Strawberries | 5.0 | 85.9 | .9 | .6 | 7.0 | .6 | 150 |
| Watermelons | 59.4 | 37.5 | .2 | .1 | 2.7 | .1 | 50 |
| Fruits, dried: | | | | | | | |
| Apples | ........ | 28.1 | 1.6 | 2.2 | 66.1 | 2.0 | 1,185 |
| Apricots | ........ | 29.4 | 4.7 | 1.0 | 62.5 | 2.4 | 1,125 |
| Dates | 10.0 | 13.8 | 1.9 | 2.5 | 70.6 | 1.2 | 1,275 |
| Figs | ........ | 18.8 | 4.3 | .3 | 74.2 | 2.4 | 1,280 |
| Raisins | 10.0 | 13.1 | 2.3 | 3.0 | 68.5 | 3.1 | 1,265 |
| Nuts: | | | | | | | |
| Almonds | 45.0 | 2.7 | 11.5 | 30.2 | 9.5 | 1.1 | 1,515 |
| Brazil nuts | 49.6 | 2.6 | 8.6 | 33.7 | 3.5 | 2.0 | 1,655 |
| Butternuts | 86.4 | .6 | 3.8 | 8.3 | .5 | .4 | 385 |
| Chestnuts, fresh | 16.0 | 37.8 | 5.2 | 4.5 | 35.4 | 1.1 | 915 |
| Chestnuts, dried | 24.0 | 4.5 | 8.1 | 5.3 | 56.4 | 1.7 | 1,385 |
| Cocoanuts | [b] 48.8 | 7.2 | 2.9 | 25.9 | 14.3 | .9 | 1,295 |
| Cocoanut, prepared | ........ | 3.5 | 6.3 | 57.4 | 31.5 | 1.3 | 2,865 |
| Filberts | 52.1 | 1.8 | 7.5 | 31.3 | 6.2 | 1.1 | 1,430 |
| Hickory nuts | 62.2 | 1.4 | 5.8 | 25.5 | 4.3 | .8 | 1,145 |
| Pecans, polished | 53.2 | 1.4 | 5.2 | 33.3 | 6.2 | .7 | 1,465 |
| Peanuts | 24.5 | 6.9 | 19.5 | 29.1 | 18.5 | 1.5 | 1,775 |
| Piñon (*Pinus edulis*) | 40.6 | 2.0 | 8.7 | 36.8 | 10.2 | 1.7 | 1,730 |
| Walnuts, black | 74.1 | .6 | 7.2 | 14.6 | 3.0 | .5 | 730 |
| Walnuts, English | 58.1 | 1.0 | 6.9 | 26.6 | 6.8 | .6 | 1,250 |
| Miscellaneous: | | | | | | | |
| Chocolate | ........ | 5.9 | 12.9 | 48.7 | 30.3 | 2.2 | 2,625 |
| Cocoa, powdered | ........ | 4.6 | 21.6 | 28.9 | 37.7 | 7.2 | 2,160 |
| Cereal coffee, infusion (1 part boiled in 20 parts water) [c] | ........ | 98.2 | .2 | ........ | 1.4 | .2 | 30 |

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[a] Fruits contain a certain proportion of inedible materials, as skin, seeds, etc., which are properly classed as refuse. In some fruits, as oranges and prunes, the amount rejected in eating is practically the same as refuse. In others, as apples and pears, more or less of the edible material is ordinarily rejected with the skin and seeds and other inedible portions. The edible material which is thus thrown away, and should properly be classed with the waste, is here classed with the refuse. The figures for refuse here given represent, as nearly as can be ascertained, the quantities ordinarily rejected.

[b] Milk and shell.

[c] The average of five analyses of cereal coffee grain is: Water 6.2, protein 13.3, fat 3.4, carbohydrates 72.6, and ash 4.5 per cent. Only a portion of the nutrients, however, enter into the infusion. The average in the table represents the available nutrients in the beverage. Infusions of genuine coffee and of tea like the above contain practically no nutrients.

## PROPORTIONS OF NONNUTRIENTS IN FOODS.

It will be interesting to note some of the differences in food materials as shown by their composition. One of the first things which may be observed when a table like the above is studied, is the differences in the proportions of nonnutrients, i. e., refuse and water. Many kinds of food as they are purchased contain large amounts of refuse, as the skin and bones of meat and fish, the skin or rind and seeds of vegetables, etc., which necessarily lessen the proportion of nutrients. While such refuse is found in meats, fish, eggs, fresh vegetables, and fruits, it is usually absent in the dairy products (milk, butter, cheese, etc.), dried vegetables, cereal foods (flour, breakfast foods, etc.), and the bread, cakes, and other foods prepared from them. In considering the edible portion we find that the amount of water present so affects the nutritive value of food. Water is necessary to the dy, and it is usually supplied in abundance by beverages, although e amount contained in the solid food consumed in a day is quite nsiderable. Water forms from 40 to 50 per cent of the ordinary ts of meat; it is especially abundant in the flesh of lean animals, nd tends to decrease as fat increases, and vice versa. It is even ore abundant in fresh fish than in meats, but in dried fish there is of urse comparatively little. Fresh vegetables and fruits contain metimes as much as 80 or 90 per cent or more of water, while dried eds and the food materials prepared from them (beans, peas, meals, our, cereal breakfast foods, etc.) usually contain, roughly speaking, om 10 to 12 per cent of water. Many cooked foods contain more ater than the raw materials from which they are made, owing to the uantities added in cooking. Thus some thin soups are little more han flavored and colored water, and of course have an extremely ow nutritive value. In other cooked foods, notably meat, which ave been baked, roasted, or fried, the amount of water is diminished by cooking.

### PROPORTIONS OF NUTRIENTS IN FOODS.

The most important of the actual nutrients has been seen to be protein. This occurs most abundantly in animal foods—meat, fish, eggs, and dairy products, and in the dried legumes, as beans and peas. Butter and lard are exceptions to this statement, as they represent the fat of milk and meat. The proportion of protein present in meats and fish varies greatly with the kind and cut. In beef, veal, and mutton it composes between 14 and 26 per cent of the edible portion. It is generally less abundant in the flesh of fish, because the latter is more watery than meat. The fatter the meat the smaller is the proportion of protein; lean pork has less than beef and mutton, and fat pork almost none. It is more abundant in cheese (28–38 per cent) and likewise in dried beans and peas (18–25 per cent). Protein makes up, roughly speaking, from 7 to 15 per cent of the cereals, being least abundant in rye and buckwheat and most abundant in oats. Wheat flour averages not far from 11 per cent and bread not far from 9 per cent of protein. Fresh vegetables and fruits contain almost no protein, seldom if ever more than 5 and often only 1 per cent or less.

The chief sources of fat in ordinary diet are the animal foods, though some fat is derived from vegetable foods. The quantities present in meats vary considerably, ranging from less than 10 per cent in some cuts of beef and veal to over 40 per cent in a side of pork and over 80 per cent in fat salt pork. The leaner fish, like cod and haddock, usually contain almost none, but in the fatter kind, like shad, mackerel, and notably salmon, there is often from 5 to 10 per cent and sometimes as much as 15 per cent of fat. The chemical composition of salmon is not unlike that of lean meat. In both meat and fish the increase of fat usually means a decrease in the proportion of water, as was stated above. Milk averages about 4 per cent of fat. Butter is, as we have seen, nearly pure fat, and whole milk cheese may have anywhere from 25 to 40 per cent of fat, according to the richness of the cream or milk from which it is made.

The olive and the cotton-seed are rich in fat, large quantities of them being used annually for the production of oils. Most of our common edible nuts also contain considerable fat. With the exception of oatmeal, which contains about 7 per cent, there is comparatively little fat in the cereals in the form in which they are ordinarily purchased, or in the dried legumes, while in the green vegetables and most fruits it is practically wanting.

The carbohydrates, unlike the fats, are almost entirely absent from the animal foods, except milk, but form the most important nutrient of most vegetable foods. Some glycogen (a carbohydrate) is found in the liver and in other animal tissues. The carbohydrates make up from 70 to 80 per cent of the cereals, 60 to 70 per cent of the dried legumes, and the bulk of the nutrients of fresh vegetables and fruits. The nutrients of sugar, molasses, honey, etc., are, of course, almost entirely carbohydrates.

Mineral matters occur in all the ordinary articles of food. Fresh meats and fish contain not far from 1 per cent, although in fat, unsalted pork the quantity may be as small as 0.1 per cent. Milk contains about 0.7 per cent mineral matters. In the cereals the proportion ranges from about 0.3 to over 2 per cent, while in green vegetables and fruits it is usually less than 1 per cent. The dried legumes contain from 3 to 4 per cent of mineral matters.

In brief, then, it may be said that meats, fish, eggs, milk, fresh vegetables, and fruits contain the most refuse and water; that protein is most abundant in the animal foods and in the legumes and occurs in considerable quantities in the cereals; that fats occur principally in the animal foods; that carbohydrates are found almost exclusively in the vegetable products and milk; and that small quantities of mineral matters are found in all food materials. The fuel value varies within wide limits, being greatest in those materials which contain the most fat and the least water.

## DIGESTION, ASSIMILATION, AND EXCRETION.

"We live not upon what we eat, but upon what we digest." Food as we buy it in the market, or even as we eat it, is not usually in condition to be made into body structure or used as body fuel. It must first go through a series of chemical changes by what is called digestion, which prepare it to be absorbed, taken into the blood and lymph, and carried

parts of the body where it is needed. Digestion takes place in
imentary canal, partly in the stomach, but more in the intestine.
e result, the useless portions are separated and rejected, while
arts which can serve for nutriment are changed into forms in
they can be absorbed, taken into the circulation, and utilized.

## DIGESTION.

alterations which the food undergoes in digestion are brought
by substances called ferments, which are secreted by the digest-
gans. The saliva in the mouth has the power of changing
ble starches into soluble sugar, but as the food stays in the
only a short time, there is generally little chance for such action.
liva, however, helps to fit the food to be more easily worked on
stomach. The gastric juice of the stomach acts upon protein,
e pancreatic juice of the intestine upon protein, fats, and carbo-
tes. The action of all the ferments is aided by the fine division
food by chewing and by the muscular contractions, the so-called
altic action, of the stomach and intestine. These latter motions
o mix the digestive juices and their ferments with the food.

parts of the food which the digestive juices can not dissolve, and
therefore escape digestion, are periodically given off by the
ne. Such solid excreta, or feces, include not only the particles
ligested food, but also the so-called metabolic products, i. e.,
es of the digestive juices, bits of the lining of the alimentary
etc.

## ABSORPTION AND ASSIMILATION.

digested food finds its way through the walls of the alimentary
and at this time and later it undergoes remarkable chemical
s. When finally the blood, supplied with the nutrients of the
d food and freighted with oxygen from the lungs, is pumped
he heart all over the body it is ready to furnish the organs and
with the materials and energy which they need for their pecul-
ctions; at the same time it carries away the waste which the
e of these functions has produced. It is a characteristic of
body tissue that it can choose the necessary materials from the
and build them into its own structure. How it does this is one
mysteries of physiology. The body, as we have learned, has
e power of consuming not only the materials of the food, but also
f its own structure for the production of muscular work, or heat,
rotect more important parts from consumption. How it does
another mystery, still to be explained.

## EXCRETION.

After the material has been thus assimilated and utilized the resulting waste products must be removed from the body. The chemical elements which this waste contains are of course the same as those making up the structure of the body and the food—carbon, oxygen, hydrogen, nitrogen, calcium, phosphorus, sulphur, etc. Most of the carbon and part of the oxygen are given off from the lungs as carbon dioxid. Hydrogen unites with more oxygen to form water, which is passed off in vapor from the lungs, in perspiration from the skin, and in urine from the kidneys. Almost all the nitrogen is excreted in the urine. Waste mineral matters are given off to some extent in the perspiration, but mainly through the kidneys and intestines.

## APPARENT AND ACTUAL DIGESTIBILITY.

The real nutritive value of a food, then, depends not simply on the proportions of nutrients which it contains, but also on the amount of those nutrients which can be made available to the body by digestion for building material and for fuel. Part of the food eaten escapes digestion and is given off from the body in the feces. If we subtract the amount of this undigested residue from the total food, the remainder will be the amount actually digested in the stomach and intestines absorbed through their walls, and taken into the circulation. This difference between the amounts eaten and those undigested represents the actual digestibility of food. A part of the food taken into the circulation, however, is later returned again to the alimentary canal mainly in the digestive juices that are needed for digesting the food. The material thus removed from circulation and returned to the alimentary canal, which consists of so-called metabolic products, is excreted with the undigested residue in the feces. The remainder of the food taken into the circulation represents the amount retained by the body for building material and for fuel. The difference between the food which is absorbed and that which the body secures, therefore, is represented by the metabolic products. By the present methods of experimenting, however, the portion of the feces that consists of metabolic products can not be satisfactorily distinguished from the undigested residue. It is very difficult, therefore, to determine the actual digestibility, but comparatively easy to estimate the apparent digestibility of food.[a]

Suppose, for instance, that 15 per cent of the protein in a specimen of bread is excreted, then 85 per cent remains for the use of the body.

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[a] It would be more exact to use different terms to denote the apparent digestibility of food as distinguished from its actual digestibility. It has therefore been proposed to limit the use of the term digestibility to actual digestibility and employ the term availability when apparent digestibility, as ordinarily determined in nutrition investigations, is meant. (See Connecticut Storrs Station Report 1899, p. 69.)

he bread has 8.4 per cent of protein, 100 pounds will have 8.4 nds, of which 85 per cent or 7.1 pounds will be utilized by the y. Table III (p. 28) gives details regarding the proportions of stible nutrients in different food materials.

### EASE AND QUICKNESS OF DIGESTION.

he terms digestible, indigestible, etc., as here used refer simply to food which is or is not available for the general nourishment of body after the process of digestion is completed. In common lance, however, they are used more loosely as referring to the ease l quickness of digestion, and to the general healthfulness of food. e kind of food—bread, for instance—is spoken of as "simple" and ligestible," and another, like fruit cake, as "rich" and "indigestle." There is often much practical truth behind such statements, ough little is definitely known concerning the time or labor required digest different kinds of food.

Among the earliest and most famous experiments concerning the ne required for digestion in the stomach are those made by Dr. Wilm Beaumont, U. S. A., between 1825 and 1833. His subject was a ench-Canadian trapper, a man quite normal except for an aperture rough the abdomen into the stomach made by a gunshot wound, and sed only by a valve which had developed over it. By pressing the lve inward the contents of the stomach could be observed or removed will, thus affording excellent opportunity to study the action of the stric juice. Dr. Beaumont fed the man on various diets, and noted e different conditions accompanying each. The book in which he scribes his experiments [a] contains a table of the average time required r the stomach to digest various articles of diet, from which many of e statements still current concerning the relative digestibility of fferent foods are taken.

One of Dr. Beaumont's general deductions was that most of the mmon foods required from 2 to 4 hours. He says further:

"The time required for the digestion of food is various, depending on the quantity and quality of the food, state of the stomach, etc., t the time ordinarily required for the disposal of a moderate meal the fibrous parts of meat, with bread, etc., is from 3 to 3½ hours."

Valuable and interesting as Dr. Beaumont's book undoubtedly is, its nclusions can not be taken as final, because he does not state the nounts of food consumed. The science of nutrition in its developent has also shown many errors in the reasoning. It should in juse be said that Dr. Beaumont recognized the fact that his experients had to do only with digestion in the stomach, or "chymification," as he terms it. Furthermore, his experiments have been often misquoted and given a different interpretation from that which he intended.

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[a] William Beaumont, The Physiology of Digestion, with Experiments on the Gastric Juice. ed. Burlington, Vt., 1847.

Food does not ordinarily pass from the stomach into the intestine until it has been reduced to a liquid or semiliquid condition. The length of time required for different foods to leave the stomach has been recently studied by Penzoldt with healthy men. He used a stomach tube for removing the stomach contents for examination. He found that the amount and consistency of food have a marked influence on the rate of digestion in the stomach. Fluids leave the stomach more rapidly than other materials. From 6 to 7 ounces of water or other common beverages leave the stomach in 1½ hours. Seven ounces of boiled milk leave the stomach in about 2 hours. Hot drinks do not leave the stomach more quickly than cold ones, nor does the quantity have much effect. Solid matter in solution or suspension delayed the passage of fluid from the stomach somewhat. The consistency of solid foods thus seems to have more effect upon digestibility than the amount consumed. The quantity eaten increases the length of time the material remains in the stomach, but not proportionally.

To select a few examples of the time required for foods to leave the stomach: Two eggs (raw, poached, or in the form of an omelet), 7 ounces sweetbreads, 10 moderate-sized oysters, 7 ounces white-fish or 3½ ounces of white bread, cauliflowers, or cherries, each left the stomach in from 2 to 3 hours. Eight and one-fourth ounces of chicken, 9 ounces of lean beef, 6 ounces boiled ham, 3½ ounces roast veal or beefsteak, 5⅓ ounces of coarse bread, boiled rice, carrots, spinach, radish, or apple, left the stomach in 3 to 4 hours. Nine ounces of smoked tongue, 3½ ounces smoked beef, 9 ounces roast goose, 5⅓ ounces string beans, or 7 ounces peas porridge, left the stomach in 4 to 5 hours.

Generally speaking, the most readily digested animal foods were materials of soft consistency. White meats—for example, chicken—leave the stomach more quickly than red meats or dark meat—for instance, duck. The method of cooking also exerts a very marked influence on stomach digestion. Fresh fish was found to be more readily digested than meats.

As regards vegetable foods in general, the consistency and the amounts of solid material were again the principal factors affecting the time required for digestion in the stomach. Mealy potatoes, for instance, were more easily digested than waxy potatoes, and mashed potato more readily than potato cut up in pieces. Fine bread was more quickly digested than coarse bread. There was not much difference in the time required for bread crust, bread crumb, toast, new bread, and stale bread to digest in the stomach, provided all were equally well chewed.

It must be remembered that digestion continues in the intestine and that the total time required for the digestion and absorption of the nutrients in any given food material is not shown by such experiments. They find their chief application in prescribing a diet for invalids, as in such cases it is often desirable to require of the stomach only a limited amount of work.

## AGREEMENT OF FOOD WITH INDIVIDUALS.

Digestibility is often confused with another very different thing, namely, the agreeing or disagreeing of food with the person who eats it. During the process of digestion and assimilation the food, as we have seen, undergoes many chemical changes, some of them in the intestines, some in the liver, muscles, and other organs. In these changes chemical compounds may be formed which are in one way or another unpleasant and injurious, especially if they are not broken down (as normally they are) before they have opportunity thus to act. Some of the compounds produced from the food in the body may be actually poisonous.

Different persons are differently constituted with respect to the chemical changes which their food undergoes and the effect produced, so that it may be literally true that "one man's meat is another man's poison." Milk is for most people a very wholesome, digestible, and nutritious food, but there are persons who are made ill by drinking it, and they should avoid milk. The writer knows a boy who is made seriously ill by eating eggs. A small piece of sweet cake in which eggs have been used will cause him serious trouble. The sickness is nature's evidence that eggs are for him an unfit article of food. Some persons have to avoid strawberries. Indeed, cases in which the most wholesome kinds of food are hurtful to individual persons are, unfortunately, numerous. Every man must learn from his own experience what food agrees with him and what does not.

How much harm is done by the injurious compounds sometimes formed from ordinary wholesome foods is seldom realized. Physiological chemistry is revealing the fact that these compounds may affect even the brain and nerves, and that some forms of insanity are caused by products formed by the abnormal transformations of food and body material.

## PROPORTIONS OF DIGESTIBLE NUTRIENTS IN FOOD MATERIALS.

During the past few years many experiments have been made to test the proportions of nutrients digested from ordinary food materials. In making the experiments the subjects are kept on a simple diet, all the food and solid excreta are analyzed, and the difference between the two is taken to represent the amount of food which the body secures for nutriment. Most of the subjects have been people in good health; the great majority have been men, but a few women, and especially children.

From comparison of the results of many such experiments much interesting knowledge has been gained of the relative digestibility of different kinds and classes of foods.

In general it may be said that probably most foods used by man are more completely digested than is ordinarily supposed, so that the bulk of the intestinal excretion is made up of metabolic products. Some foods, however, contain large proportions of material upon which the digestive juices can not so act as to make them capable of being absorbed. Thus the outer hull of the wheat grain contains woody substance which passes through the alimentary canal of man undigested, though animals, like cows and sheep, can digest a large part of it.

It has been found that in the total food of an ordinary mixed diet, on the average, about 92 per cent of the protein, 95 per cent of the fats, and 97 per cent of the carbohydrates are retained by the body. In the average proportions in which the different animal and vegetable foods are combined in the diet about 97 per cent of the protein, 95 per cent of the fats, and 98 per cent of the carbohydrates of the animal foods are digested, while only 84 per cent of the protein, 90 per cent of the fats, and 97 per cent of the carbohydrates of the vegetable foods are digested. Animal foods, therefore, seem to have a greater digestibility than vegetable, especially as regards the protein they contain. The digestibility of a given article of food depends, of course, upon the digestibility of the different classes of nutrients and upon the relative proportion in which these nutrients occur. Thus, of two cereals containing about the same amount of dry matter, but with different proportions of protein and carbohydrates, the one with the larger proportion of the less digestible protein and the smaller proportion of the more digestible carbohydrates will be, on the whole, less completely digested.

The figures given in Table I (p. 16) do not, then, represent the nutrients actually available for the uses of the body, but those contained in the food before it is eaten. The nutrients actually available must be calculated from the total amounts shown in the table by use of the proper factors for digestibility. Thus if 53.1 per cent of bread is carbohydrates the percentage of carbohydrates which the body will obtain from a given amount of bread will be 98 per cent of 53.1, or 52 per cent of the weight of the bread. Similarly the fuel value given is not the heat of combustion of the food consumed, but that of the nutrients actually oxidized in the body. This fuel value may be calculated from the proportions of digestible nutrients and the fuel values of each as learned by experiment.

The proportions of the several nutrients which the body retains for its use are commonly called percentages or coefficients of digestibility.[a] From the results of a large amount of experimenting it appears that the coefficients of digestibility and the fuel value per pound of different food materials or groups of materials are approximately as follows:

TABLE II.—*Coefficients of digestibility and fuel value per pound of nutrients in different groups of food materials.*

| Kind of food. | Protein. | | Fat. | | Carbohydrates. | |
|---|---|---|---|---|---|---|
| | Digestibility. | Fuel value per pound. | Digestibility. | Fuel value per pound. | Digestibility. | Fuel value per pound. |
| | *Per cent.* | *Calories.* | *Per cent.* | *Calories.* | *Per cent.* | *Calories.* |
| Meats and fish | 97 | 1,940 | 95 | 4,040 | 98 | 1,730 |
| Eggs | 97 | 1,980 | 95 | 4,090 | 98 | 1,730 |
| Dairy products | 97 | 1,940 | 95 | 3,990 | 98 | 1,730 |
| Animal food (of mixed diet) | 97 | 1,940 | 95 | 4,050 | 98 | 1,730 |
| Cereals | 85 | 1,750 | 90 | 3,800 | 98 | 1,860 |
| Legumes (dried) | 78 | 1,570 | 90 | 3,800 | 97 | 1,840 |
| Sugars | ........ | ........ | ........ | ........ | 98 | 1,750 |
| Starches | ........ | ........ | ........ | ........ | 98 | 1,860 |
| Vegetables | 83 | 1,410 | 90 | 3,800 | 95 | 1,800 |
| Fruits | 85 | 1,520 | 90 | 3,800 | 90 | 1,630 |
| Vegetable foods (of mixed diet) | 84 | 1,840 | 90 | 3,800 | 97 | 1,820 |
| Total food (of mixed diet) | 92 | 1,820 | 95 | 4,050 | 97 | 1,820 |

The figures of Table III (p. 28) show the digestible nutrients and available energy in a number of common food materials, as computed from the figures in Table I, by use of the factors given in Table II. The further assumption is made that 75 per cent of the ash is digestible. The figures in the third column of Table III show the total quantity of indigestible nutrients. The term used as the heading of the last column, "nutritive ratio," or, as it is sometimes and perhaps more accurately called, "nutrient ratio," requires a word of explanation. The term nutritive ratio is used to express the ratio of digestible protein to digestible fuel ingredients (fats and carbohydrates) in any food material or diet. In calculating this ratio 1 pound of fat is taken as equivalent to 2¼ pounds of carbohydrates—this being approximately the ratio of their fuel values—so that the nutritive ratio is actually that of the protein to the carbohydrates plus 2¼ times the fat.

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[a] It should be understood that the terms "digestibility" and "digestible nutrients" and "coefficients of digestibility," as used in the following tables and the accompanying explanations, refer to apparent digestibility (see p. 22).

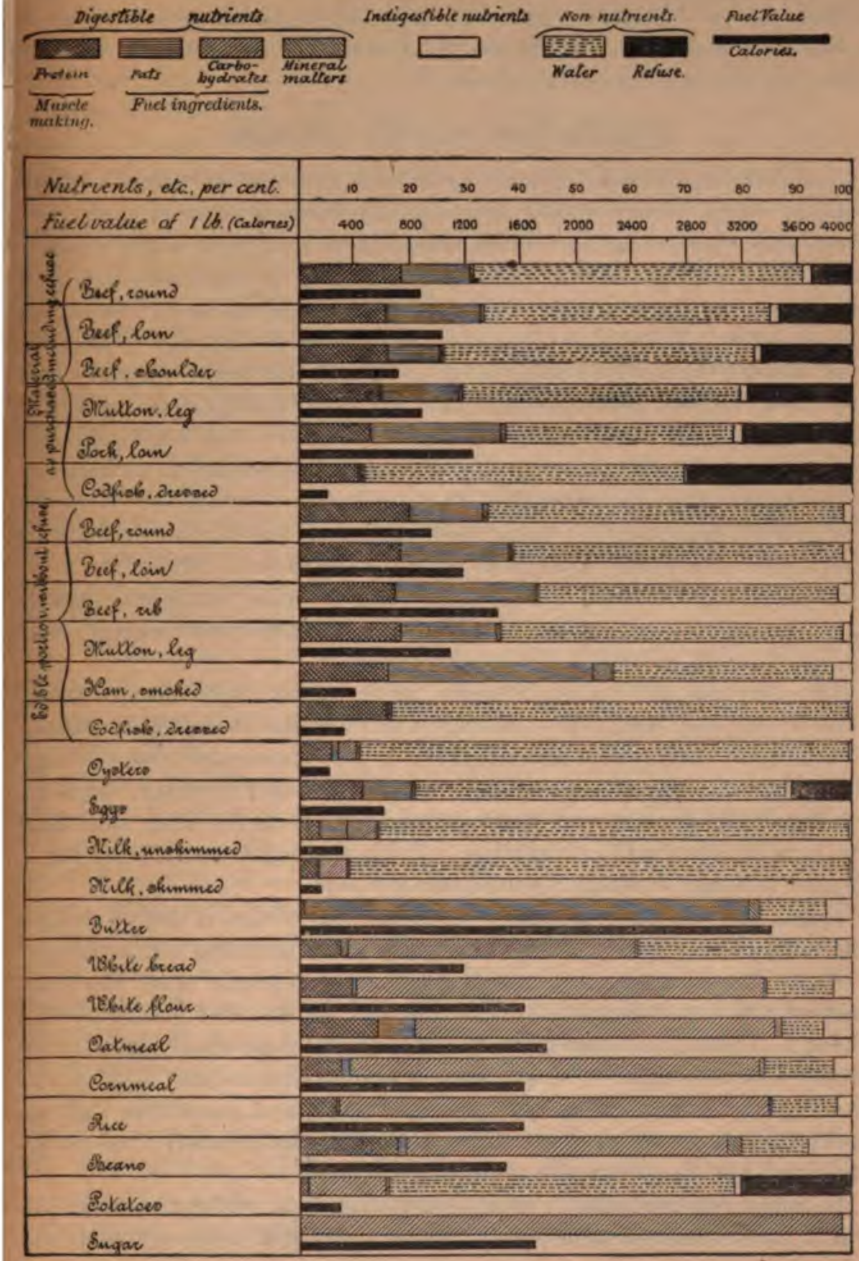
**TABLE III.**—*Nutrients and energy of digestible portion of some common foods, nutritive ratios.*

| Kind of food materials. | Refuse. | Water. | Total indigestible nutrients. | Digestible nutrients. | | | | Fuel value per pound. |
|---|---|---|---|---|---|---|---|---|
| | | | | Protein. | Fat. | Carbohydrates. | Ash. | |
| ANIMAL FOOD. | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Calories.* |
| Beef, fresh: | | | | | | | | |
| Chuck, ribs | 16.3 | 52.6 | 1.4 | 15 | 14.3 | ........ | 0.6 | 910 |
| Loin, medium | 13.3 | 52.5 | 1.6 | 15.6 | 16.6 | ........ | .7 | 1,025 |
| Ribs | 20.8 | 43.8 | 1.8 | 13.5 | 20 | ........ | .5 | 1,135 |
| Round, medium | 7.2 | 60.7 | 1.4 | 18.4 | 12.2 | ........ | .8 | 890 |
| Shoulder and clod | 16.4 | 56.8 | 1.2 | 15.9 | 9.3 | ........ | .7 | 715 |
| Beef, dried and smoked | 4.7 | 53.7 | 4.5 | 25.6 | 6.6 | ........ | 5.5 | 790 |
| Veal: | | | | | | | | |
| Cutlets, round | 3.4 | 68.3 | 1.2 | 10.5 | 7.1 | ........ | .8 | 695 |
| Leg | 14.2 | 60.1 | 1.1 | 15 | 7.5 | ........ | .7 | 625 |
| Mutton: | | | | | | | | |
| Leg | 18.4 | 51.2 | 1.4 | 14.6 | 14 | ........ | .6 | 890 |
| Loin | 16 | 42 | 2 | 13.1 | 26.9 | ........ | .5 | 1,415 |
| Pork, fresh: | | | | | | | | |
| Loin, chops | 19.7 | 41.8 | 1.8 | 13 | 23 | ........ | .6 | 1,245 |
| Ham | 10.7 | 48 | 1.9 | 13.1 | 24.6 | ........ | .6 | 1,320 |
| Pork, salted and smoked: | | | | | | | | |
| Bacon | 7.7 | 17.4 | 4.4 | 8.8 | 59.1 | ........ | 3.1 | 2,720 |
| Ham | 13.6 | 34.8 | 3.1 | 13.8 | 31.7 | ........ | 3.2 | 1,635 |
| Salt, fat | ........ | 7.9 | 5.4 | 1.8 | 81.9 | ........ | 2.9 | 3,555 |
| Poultry: | | | | | | | | |
| Fowl | 25.9 | 47.1 | 1.2 | 13.3 | 11.7 | ........ | .5 | 765 |
| Turkey | 22.7 | 42.4 | 1.6 | 15.6 | 17.5 | ........ | .6 | 1,060 |
| Fish, fresh: | | | | | | | | |
| Cod, dressed | 29.9 | 58.5 | .5 | 10.8 | .2 | ........ | .6 | 220 |
| Mackerel | 44.7 | 40.4 | .7 | 9.9 | 4 | ........ | .5 | 370 |
| Shellfish: | | | | | | | | |
| Oysters, solids | ........ | 88.3 | .6 | 5.8 | 1.2 | 3.3 | .8 | 225 |
| Fish, preserved and canned: | | | | | | | | |
| Cod, salt | 24.9 | 40.2 | 5.1 | 15.5 | .4 | ........ | 13.9 | 325 |
| Salmon, canned | ........ | 63.5 | 1.9 | 21.1 | 11.5 | ........ | 2 | 915 |
| Eggs, uncooked | 11.2 | 65.5 | 1.1 | 12.7 | 8.8 | ........ | .7 | 635 |
| Dairy products: | | | | | | | | |
| Whole milk | ........ | 87 | .5 | 3.2 | 3.8 | 5 | .5 | 310 |
| Skim milk | ........ | 90.5 | .3 | 3.3 | .3 | 5.1 | .5 | 165 |
| Cream | ........ | 74 | 1.1 | 2.4 | 17.6 | 4.5 | .4 | 865 |
| Butter | ........ | 11 | 4.9 | 1 | 80.8 | ........ | 2.3 | 3,410 |
| VEGETABLE FOOD. | | | | | | | | |

The principal data included in Table III are shown in graphic form in Chart 1.

CHART 1.—COMPOSITION OF FOOD MATERIALS.

*Nutritive ingredients, refuse, and fuel value.*



It is to be observed that the values given in Table III, like those of Table I, represent averages. Different specimens of the same kind of food material differ in composition, digestibility, and nutritive value. Materials which are grouped in the same class may also differ more or less in this respect. Thus potatoes, turnips, cabbage, or even different specimens of the same vegetable, may differ in the proportions of nutrients digested. The figures in Table III, therefore, are to be taken as only approximate values.

## PREPARATION OF FOOD—COOKING.

The cooking of food has much to do with its nutritive value. Many articles which, owing to their mechanical condition or other cause, are quite unfit for nourishment when raw are very nutritious when cooked. It is also a matter of common experience that a well-cooked food is wholesome and appetizing, while the same material badly cooked is unpalatable. There are three chief purposes of cooking. The first is to change the mechanical condition so that the digestive juices can act upon the food more freely. Heating often changes the structure of food materials very materially, so that they are more easily chewed and more easily and thoroughly digested. The second is to make it more appetizing by improving the appearance or flavor, or both. Food which is attractive to the taste quickens the flow of saliva and other digestive juices, and thus digestion is aided. The third is to kill by heat any disease germs, parasites, or other dangerous organisms it may contain. This is often a very important matter, and applies to both animal and vegetable foods.

The cooking of meats develops the pleasing taste and odor of extractives and that due to the browned fat and tissues and softens and loosens the protein (gelatinoids) of the connective tissues, and thus makes the meat more tender. Extreme heat, however, tends to coagulate and harden the albuminoids of the lean portions, and also weakens the flavor of extractives. If the heating is carried too far a burned or charred product of bad flavor results.

Meats lose weight in cooking. A small part of this is due to escape of meat juices and fat, but the chief part of the material lost is simply water. The nutritive value of a meat soup depends upon the substances which are dissolved out of the meat, bones, and gristle by the water. In ordinary meat broth these consist almost wholly of extractives and salts, which are very agreeable and often most useful as stimulants, but have little or no value as actual nutriment, since they neither build tissue nor yield energy. The principles which underlie the cooking of fish are essentially the same as with meats.

In many vegetables the valuable carbohydrates, chiefly microscopic ch grains, are contained in tiny cells with thick walls on which the stive juices have little effect. The heat of cooking, especially the aid of water, ruptures these walls and also makes the starch soluble. The heat also caramelizes a portion of the carbohy- es and produces agreeable flavors in this and other ways.

breads, cakes, pastry, and other foods prepared from flour, the is to make a palatable and lighter porous substance more easily en up in the alimentary canal than the raw materials could be. etimes this is accomplished simply by means of water and heat. heat changes part of the water in the dough into steam, which, in g to escape, forces the particles of dough apart. The protein en) of the flour stiffens about the tiny bubbles thus formed and mass remains porous even after the steam has escaped. More n, however, other things are used to "raise" the dough—such as t and baking powder. The baking powder gives off the gas on dioxid and the yeast causes fermentation in the dough by h carbon dioxid is produced. This acts as the steam does, only h more powerfully. When beaten eggs are used, the albumen oses air in bubbles which expand, and the walls stiffen with the t and thus render the food porous.

crupulous neatness should always be observed in keeping, hand- , and serving food. If ever cleanliness is desirable, it must be in things we eat, and every care should be taken to insure it for the of health as well as of decency. Cleanliness in this connection ns not only absence of visible dirt, but freedom from undesirable eria and other minute organisms, and from worms and other para- . If food, raw or cooked, is kept in dirty places, peddled from y carts, prepared in dirty rooms and in dirty dishes, or exposed to air, disease germs and other offensive and dangerous substances easily get in.

ood and drink may, in fact, be very dangerous purveyors of dis- . The bacteria of typhoid fever sometimes find their way into king water, and those of typhoid and scarlet fevers and diphtheria milk, and bring sickness and death to large numbers of people. ters which are taken from the salt water where they grow and ated" for a short time in brackish water near the mouth of a am, have been known to be infected by typhoid fever germs ght into the stream by the sewage from houses where the dejec- s from patients had been thrown into the drains. Celery or let- grown in soil containing typhoid germs has been thought to con- this disease.

ood materials may also contain parasites, like tapeworms in beef, , and mutton, and trichinæ in pork, which are often injurious sometimes deadly in their effect. This danger is not confined to nal foods. Vegetables and fruits may become contaminated with eggs of numerous parasites from the fertilizers applied to them. Raw fruits and vegetables should always be very thoroughly washed before serving if there is any doubt as to their cleanliness. If the food is sufficiently heated in cooking, all organisms are killed.

Sometimes food undergoes decomposition in which injurious chemical compounds, so-called ptomaines, are formed. Poisoning by cheese, ice cream, preserved fish, canned meats, and the like has been caused in this way. The ptomaines often withstand the heat of cooking.

In some cases it has been found that foods are adulterated with compounds injurious to health; but sophistication in which harmless articles of inferior cost or quality are added is more common.

Dainty ways of serving food have a usefulness beyond their æsthetic value. Everyone knows that a feeble appetite is often tempted by a tastefully garnished dish, when the same material carelessly served would seem quite unpalatable. Furthermore, many cheap articles and "left-overs" when well seasoned and attractively served may be just as appetizing as dearer ones, and will usually be found quite as nutritious.

## DIETARIES AND DIETARY STANDARDS.

The information gained from a study of the composition and nutritive value of foods may be turned to practical account by using it in planning diets for different individuals or classes of individuals or in estimating the true nutritive value of the food actually consumed by families or individuals. By comparing the results of many such investigations with the results of accurate physiological experimenting it is possible to learn about how much of each of the nutrients of common foods is needed by persons of different occupations and habits of life, and from this to compute standards representing the average requirements for food of such persons.

### METHODS OF MAKING DIETARY STUDIES.

During the last twenty years much of this practical application of the chemistry of food has been made in the study of actual dietaries. Much work of this kind has been done in England, Germany, Italy, Russia, Sweden, and elsewhere in Europe, and in Japan and other oriental countries. Within the past dozen years extensive studies have been made in the United States. The simplest way of making such inquiries is to find out what kinds and quantities of food are used during a given period in the household in which the study is made; to estimate the amounts of various nutrients which the different materials contain by means of figures given for the average composition of the various articles in tables, like Table I (p. 16), and then to calcuate the cost and amount of nutrients for each person. There are, owever, several chances for error in such a method. In the first lace, since different specimens of the same kind of food vary greatly n composition, it is often inaccurate to estimate the nutrients of one pecimen from figures representing the average composition. Accordngly, in the more careful dietary studies, the composition of the food s determined by analyzing samples of materials actually used. Again, his method assumes that all the food is really consumed, whereas it s very plain that frequently no small portion is wasted in the kitchen r at the table. This difficulty is usually met by measuring and computing the amounts of nutrients in the waste and sometimes by analyzng samples of it.

In preparing the results of dietary studies so that different studies may be compared, another difficulty appears. For example, in a famly consisting of father, mother, and two children of different ages the amount of food taken by each is by no means the same, and it would quite incorrect to divide the whole amounts consumed by four and d the result the amount used per person. Men, as a rule, eat more an women, women more than young children, and persons of active habits more than those who take little muscular exercise. A coal heaver, who is constantly using up nutritive material of muscular tissue to supply the energy required for his severe muscular work, needs a diet with more protein and higher fuel value than a bookkeeper who sits at a desk all day. It is ordinarily estimated that, as compared with a man at moderate or light work, a woman under similar conditions needs 0.8 as much food, and children amounts varying with their ages, and such figures are used to reduce the statistics of a dietary to the standard of one man at moderate work. The various factors commonly used in the United States in computing the results of dietary studies are as follows:

*Factors used in calculating meals consumed in dietary studies.*

Man at hard muscular work requires 1.2 the food of a man at moderately active muscular work.

Man with light muscular work and boy 15–16 years old require 0.9 the food of a man at moderately active muscular work.

Man at sedentary occupation, woman at moderately active work, boy 13–14, and girl 15–16 years old require 0.8 the food of a man at moderately active muscular work.

Woman at light work, boy 12, and girl 13–14 years old require 0.7 the food of a man at moderately active muscular work.

Boy 10–11 and girl 10–12 years old require 0.6 the food of a man at moderately active muscular work.

Child 6–9 years old requires 0.5 the food of a man at moderately active muscular work.

Child 2–5 years old requires 0.4 the food of a man at moderately active muscular work.

Child under 2 years old requires 0.3 the food of a man at moderately active muscular work.

These factors are based in part upon experimental data and in part upon arbitrary assumptions. They are subject to revision when experimental evidence shall warrant more definite conclusions.

In making dietary studies in this country blanks are usually prepared to be filled out with statistics of the amounts, kinds, cost, and estimated nutrients of the food purchased, wasted, and actually consumed, and information concerning the number, sex, age, and occupation of the persons for whom the food is provided. If further data are gathered concerning the health, nationality, income, and general conditions of the individuals of families, the results of such inquiries have a wider physiological and sociological bearing. These supplementary statistics have been collected in considerable detail in late studies in the United States.

## AMERICAN AND EUROPEAN DIETARIES AND DIETARY STANDARDS.

Many interesting things come to light on comparing the dietaries of persons with different occupations and incomes and performing different amounts of muscular work. A comparison of the dietaries of the inhabitants of different countries is also interesting. Such comparisons are made in the following table, which includes as well the commonly accepted dietary standards. The figures show the quantities of both total and available nutrients. The fuel value represents the actual amount of available energy, and may be computed from either the total or the digestible nutrients by use of appropriate factors.[a]

TABLE IV.—*Food consumption of persons in different circumstances, and proposed dietary standards.*

[Quantities per man per day.]

| | Number of studies included in averages. | Actually eaten. | | | Digestible. | | | Fuel value. | Nutritive ratio. |
|---|---|---|---|---|---|---|---|---|---|
| | | Protein. | Fat. | Carbohydrates. | Protein. | Fat. | Carbohydrates. | | |
| PERSONS WITH ACTIVE WORK. | | *Gms.* | *Gms.* | *Gms.* | *Gms.* | *Gms.* | *Gms.* | *Calories.* | *1:* |
| Rowing clubs in New England | 7 | 155 | 177 | 440 | 143 | 168 | 427 | 3,955 | 5.6 |
| Bicyclists in New York | 3 | 186 | 186 | 651 | 171 | 177 | 631 | 5,005 | 6 |
| Football teams in Connecticut and California | 2 | 226 | 354 | 634 | 208 | 336 | 615 | 6,590 | 6.6 |
| Prussian machinists | 1 | 139 | 113 | 677 | 128 | 107 | 657 | 4,270 | 7 |
| Swedish mechanics | 5 | 189 | 110 | 714 | 174 | 104 | 693 | 4,590 | 5.3 |
| PERSONS WITH ORDINARY WORK. | | | | | | | | | |
| Farmers' families in eastern United States | 10 | 97 | 130 | 467 | 89 | 124 | 453 | 3,415 | 8.2 |
| Mechanics' families in United States | 14 | 103 | 150 | 402 | 95 | 143 | 390 | 3,355 | 7.5 |

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[a] These factors are as follows: For each gram of total nutrients, protein 4.0, fat 8.9, and carbohydrates 4.0 calories. For each gram of digestible nutrients, protein 4.4, fat 9.4, and carbohydrates 4.1 calories.

IV.—*Food consumption of persons in different circumstances, and proposed dietary standards*—Continued.

| | Number of studies included in averages. | Actually eaten. | | | Digestible. | | | Fuel value. | Nutritive ratio. |
|---|---|---|---|---|---|---|---|---|---|
| | | Protein. | Fat. | Carbohydrates. | Protein. | Fat. | Carbohydrates. | | |
| **'S WITH ORDINARY WORK—continued.** | | | | | | | | | |
| | | *Gms.* | *Gms.* | *Gms.* | *Gms.* | *Gms.* | *Gms.* | *Calories.* | 1: |
| ' families in large cities of States | 12 | 101 | 116 | 344 | 93 | 110 | 334 | 2,810 | 6.3 |
| ' families in United States omfortable circumstances) | 2 | 120 | 147 | 534 | 110 | 140 | 518 | 3,925 | 7.6 |
| peasants | ...... | 129 | 33 | 589 | 119 | 31 | 571 | 3,165 | 5.4 |
| mechanics | 6 | 134 | 79 | 523 | 123 | 75 | 507 | 3,330 | 5.5 |
| **PROFESSIONAL MEN.** | | | | | | | | | |
| teachers, etc., in United | 14 | 104 | 125 | 423 | 96 | 119 | 410 | 3,220 | 7.1 |
| ubs in United States | 15 | 107 | 148 | 459 | 98 | 141 | 445 | 3,580 | 7.8 |
| physicians | 2 | 131 | 95 | 327 | 121 | 90 | 317 | 2,680 | 4.3 |
| professor | 1 | 123 | 21 | 416 | 113 | 19 | 403 | 2,345 | 4 |
| **TH LITTLE OR NO EXERCISE.** | | | | | | | | | |
| erican) in respiration calo- | 11 | 112 | 80 | 305 | 103 | 76 | 296 | 2,380 | 4.5 |
| rman) in respiration appa- | 5 | 127 | 80 | 302 | 117 | 76 | 293 | 2,430 | 4 |
| **IN DESTITUTE CIRCUMSTANCES.** | | | | | | | | | |
| ilies in New York City | 11 | 93 | 95 | 407 | 86 | 90 | 395 | 2,845 | 6.9 |
| ' families in Pittsburg, Pa | 2 | 80 | 95 | 308 | 74 | 90 | 299 | 2,400 | 6.8 |
| laborer's family | 1 | 52 | 32 | 287 | 48 | 30 | 278 | 1,640 | 7.2 |
| echanics | 5 | 76 | 38 | 396 | 70 | 36 | 384 | 2,225 | 6.6 |
| **MISCELLANEOUS.** | | | | | | | | | |
| milies in Alabama and Vir- | 39 | 86 | 145 | 440 | 79 | 138 | 427 | 3,395 | 9.3 |
| milies in Chicago | 4 | 103 | 111 | 391 | 95 | 105 | 379 | 2,965 | 6.5 |
| anadians in Chicago | 5 | 118 | 158 | 345 | 109 | 150 | 335 | 3,260 | 6.2 |
| n families in Chicago | 8 | 115 | 101 | 360 | 106 | 96 | 349 | 2,800 | 5.3 |
| nts Java village, Columbian tion, 1893 | 1 | 66 | 19 | 254 | 61 | 18 | 246 | 1,450 | 4.7 |
| Jews in Chicago | 10 | 137 | 103 | 418 | 126 | 98 | 405 | 3,135 | 5 |
| families in New Mexico | 4 | 94 | 71 | 613 | 86 | 67 | 595 | 3,460 | 8.7 |
| entist in California | 1 | 115 | 113 | 289 | 106 | 107 | 280 | 2,620 | 4.9 |
| aundryman in California | 1 | 135 | 76 | 566 | 124 | 72 | 549 | 3,480 | 5.7 |
| arm laborer in California | 1 | 144 | 95 | 640 | 132 | 90 | 621 | 3,980 | 6.2 |
| tates Army ration, peace | ...... | 120 | 161 | 454 | 110 | 153 | 440 | 3,730 | 7.1 |
| army ration, peace | ...... | 114 | 39 | 480 | 105 | 37 | 466 | 2,725 | 5.2 |
| **DIETARY STANDARDS.** | | | | | | | | | |
| ard work (Voit) | ...... | 145 | 100 | 450 | 133 | 95 | 437 | 3,270 | 4.9 |
| oderate work (Voit) | ...... | 118 | 56 | 500 | 109 | 53 | 485 | 2,965 | 5.5 |
| very hard muscular work er) | ...... | 175 | (a) | (a) | 161 | (a) | (a) | 5,500 | 7.2 |
| hard muscular work (At- | ...... | 150 | (a) | (a) | 138 | (a) | (a) | 4,150 | 6.2 |
| moderately active muscular Atwater) | ...... | 125 | (a) | (a) | 115 | (a) | (a) | 3,400 | 6.2 |
| light to moderate muscular Atwater) | ...... | 112 | (a) | (a) | 103 | (a) | (a) | 3,050 | 6.1 |
| sedentary" or woman with tely active work (Atwater) | ...... | 100 | (a) | (a) | 92 | (a) | (a) | 2,700 | 6.1 |
| t light to moderate muscular or man without muscular (Atwater) | ...... | 90 | (a) | (a) | 83 | (a) | (a) | 2,450 | 6.1 |

nd carbohydrates in sufficient amounts to furnish, together with the protein, the indicated f energy.

The dietary standards[a] given in the table (pp. 34, 35) are based, as far as possible, upon the results of observation and experiment, but are at best general estimates and not guides to be blindly followed. They are subject to revision in the light of further experimental evidence. It will be observed that the amounts of energy provided in the American standards are somewhat larger than in the European standards (Voit's). This corresponds to the observed fact that people in this country, more especially the working people, are as a rule better fed and do more work than those of corresponding classes in Europe. The quantities of protein in these standards are larger in proportion to the fuel ingredients—that is, the nutritive ratio is narrower—than is found in the average American diet. In this respect the standards agree more nearly with the diet of well-to-do people in Europe. It is believed that the larger amount of protein represents rather more nearly a physiological ration than do the proportions as found in the majority of actual dietaries.

The results of a large amount of experimental investigation bear out the common belief that the American, as a rule, uses more food than the European of the same class. The character of the food is, however, quite different. The poor peasants of Russia and northern Germany live chiefly upon rye bread, potatoes, and some sort of fat. In Italy maize, chestnuts, and acorn meal form an important item in the diet of a considerable portion of the poorer population. The use of meat among the working population of most European and Asiatic countries is very much less general than in America, because its cost is prohibitive.

In the majority of European dietaries the fats occur in relatively smaller and carbohydrates in relatively larger amounts than in American dietaries. This is probably due in large measure to the smaller quantities of meats used in the former dietaries.

Among the more scantily nourished peoples of the globe are the poor of India and China. They live largely on rice and other cereals and vegetables, with more or less of pulse and other legumes, and often on quantities which to the ordinary American would seem little more than a starvation diet.

A close examination of the detailed statistics from which those of Table III (p. 28) have been selected shows that, although there may be occasional wide variations between two individuals of a given class in respect to the total amounts of food eaten, yet, on the whole, through extended periods, there are not unusually large variations in amounts of protein or energy in the food consumed by different individuals of the same class; that is, under similar conditions as regards work or rest.

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[a] For several years an effort has been made to collect statistical and experimental data with a view to revising dietary standards. The amount of data at present (1906) available is very large, and the work of systematizing it is well under way. It seems probable that the revised dietary standards will differ somewhat from the standards published in this and earlier publications of this Department.

## MAKING HOME STUDIES OF DIETARIES.

Any housekeeper who wishes to know how the nutritive value of the food she provides for her family corresponds with the dietary standards can easily make a simple dietary study in her home, and by so doing can perhaps not only provide meals that are more in accordance with the needs of her family, but frequently also save money by substituting less expensive but equally nutritious and attractive food materials for some of those usually served.

The simplest way to make such a study is to weigh all different kinds of food materials in the house at a given time, say after supper, recording the weights in a convenient book. All the food purchased during the days during which the diet is being studied is weighed and recorded, and at the close of the study, which may be conveniently of seven or ten days' duration, all food materials remaining on hand are weighed as before. From the quantities of the different kinds of food on hand at the beginning and purchased during the period are subtracted the quantities left on hand at the close of the study. The difference represents the amounts used. The quantity of nutrients in the different materials is calculated from the figures for percentage composition given in Table I, or in other more comprehensive tables[a]. In order to express the quantities of nutrients in values per man per day, the number of meals taken by different members of the family are multiplied by the factors given on page 33, pointing off one decimal place. The result gives the equivalent number of meals for a man. The equivalent number of meals taken divided by 3 gives the equivalent number of days for one man. The total nutrients for the whole period, divided by this latter quantity, gives the nutrients per man per day. From these latter figures the fuel value of the diet can be computed by means of the factors given on page 33. In a similar way the value of any menu for one day or one meal may be calculated. It is to be remembered that in a short period, such as a day or two days, the diet may fluctuate according to the materials used so as to give more of one kind of nutrients and less of another, or more or less total nutrients than the average diet, while in periods of a week or ten days the diet is more likely to approach an average.

## ADAPTING FOOD TO THE NEEDS OF THE BODY.

All persons are alike in that they must have protein for the building and repair of the bodily machine and fuel ingredients for warmth and work, but individuals differ in the amounts and proportions they require, and even among those in good health there are many who are obliged to avoid certain kinds of food, while invalids and people with weak digestion must often have special diet.

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[a] See especially U. S. Dept. Agr., Office of Experiment St [illegible] 28, rev

For people in good health and with good digestion there are two important rules to be observed in the regulation of the diet. The first is to choose the things which "agree" with them, and to avoid those which they can not digest and assimilate without harm. The second is to use such kinds and amounts of food as will supply all the nutrients the body needs and at the same time avoid burdening it with superfluous material to be disposed of at the cost of health and strength.

For guidance in this selection, nature provides us with instinct, taste, and experience. Physiological chemistry adds to these the knowledge—still new and far from adequate—of the composition of food and the laws of nutrition. In our actual practice of eating we are apt to be influenced too much by taste—that is, by the dictates of the palate; we are prone to let natural instinct be overruled by acquired appetite, and we neglect the teachings of experience. We need to observe our diet and its effects more carefully and to regulate appetite by reason. In doing this we may be greatly aided by the knowledge of what our food contains and how it serves its purpose in nutrition.

Though there may be differences among abnormal persons, for the great majority of people in good health the ordinary food materials—meats, fish, eggs, milk, butter, cheese, sugar, flour, meal, and potatoes and other vegetables—make a fitting diet, and the main question is to use them in the kinds and proportions fitted to the actual needs of the body.

When more food is eaten than is needed, or when articles difficult of digestion are taken, the digestive organs are overtaxed, if not positively injured, and much energy is thus wasted which might have been turned to better account. The evils of overeating may not be felt at once, but sooner or later they are sure to appear—perhaps in an excessive amount of fatty tissue, perhaps in general debility, perhaps in actual disease. The injurious effects of food which does not "agree" with a person have already been pointed out.

## ADVANTAGES OF SEVERAL MEALS A DAY.

The theory is advanced from time to time that one or two meals a day are preferable to the three commonly served in this country. If the same amount of food is to be eaten it is hard to see the advantage of two very hearty meals over three ordinary ones. The best physiological evidence implies that moderate quantities of food taken at moderate intervals are more easily and completely digested by ordinary people than larger quantities taken at long intervals. If the food ordinarily taken is considered excessive and the aim is simply to reduce the amount, it would seem more rational to make all the meals lighter than to leave out one. The very fact that the custom of eating a number of meals a day has so long been almost universal indicates that it must have some advantages which instinct, based upon experience, approves and justifies.

## PECUNIARY ECONOMY OF FOOD.

Although the cost of food is the principal item in the living expenses a large majority of the people, and although the physical welfare of is so intimately connected with and dependent upon diet, very few ven the most intelligent have any clear ideas regarding the actual riment in the different food materials they use. In too many cases n those who wish and try to economize know very little as to the binations which are best fitted for their nourishment and have still information as to the relation between the real nutritive value of rent foods and their cost.

he question here to be considered is this: Of the different food erials which are palatable, nutritious, and otherwise suited for rishment, what ones are pecuniarily the most economical; in other ds, what ones furnish the largest amounts of available nutrients at lowest cost? In answering this question it is necessary to take account not only the prices per pound, quart, or bushel of the different materials, but also the kinds and amounts of the actual nutri- they contain and their fitness to meet the demands of the body for rishment. The cheapest food is that which supplies the most nutri- t for the least money. The most economical food is that which is pest and at the same time best adapted to the needs of the user.

here are various ways of comparing food materials with respect to relative cheapness or dearness of their nutritive ingredients. For ance, from the proportions of available nutrients and energy in rent food materials given in Table III we may calculate the cost e different nutrients per pound and of energy per 1,000 calories ny given material for which the price per pound is known. Thus, the different food materials given in Table V (p. 40), when the e of any material is that given in the first column, the cost of pro- and energy will be as given in the second and third columns. se figures show the relative economy of the various foods as sources rotein and sources of energy. Of course the amount of energy would be obtained in a quantity of any given material sufficient urnish a pound of protein would vary with the amounts of fats and ohydrates accompanying the protein; and on the other hand, the ntities of the different materials that would furnish 1,000 calories nergy would contain different amounts of protein. The figures ost of protein leave the carbohydrates and fats out of account, and e for energy take no account of the protein. Hence the figures either protein or energy alone give a very one-sided view of the rela- between nutritive value and money cost.

better way of estimating the relative pecuniary economy of differ- food materials is found in a comparison of the quantities of both rients and energy which can be obtained for a given sum, say 10

cents, at current prices. This also
follows:

TABLE V.—*Comparative cost of digestible nutrie*
*average pr*

[It is estimated that a man at light to moderate mus
and 3,050 calories of e

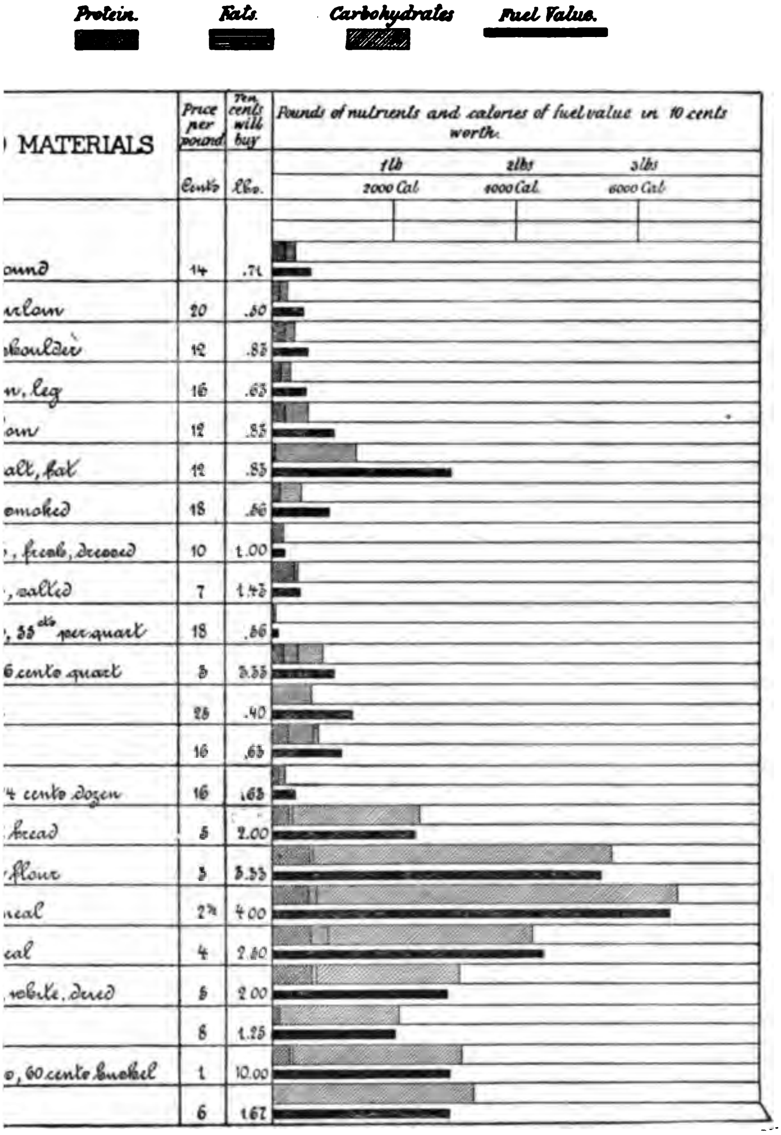
| Kind of food material. | Price per pound. | Cost of 1 pound protein.[a] | Cost 1,0 calor ener (a |
|---|---|---|---|
| | *Cents.* | *Dollars.* | *Cen* |
| Beef, sirloin | 25 | 1.60 | |
| Do | 20 | 1.28 | |
| Do | 15 | .96 | |
| Beef, round | 16 | .87 | |
| Do | 14 | .76 | |
| Do | 12 | .65 | |
| Beef, shoulder clod | 12 | .75 | |
| Do | 9 | .57 | |
| Beef, stew meat | 5 | .35 | |
| Beef, dried, chipped | 25 | .98 | |
| Mutton chops, loin | 16 | 1.22 | |
| Mutton, leg | 20 | 1.37 | |
| Do | 16 | 1.10 | |
| Roast pork, loin | 12 | .92 | |
| Pork, smoked ham | 22 | 1.60 | |
| Do | 18 | 1.30 | |
| Pork, fat salt | 12 | 6.67 | |
| Codfish, dressed, fresh | 10 | .93 | |
| Halibut, fresh | 18 | 1.22 | |
| Cod, salt | 7 | .45 | |
| Mackerel, salt, dressed | 10 | .74 | |
| Salmon, canned | 12 | .57 | |
| Oysters, solids, 50 cents per quart | 25 | 4.30 | 1 |
| Oysters, solids, 35 cents per quart | 18 | 3.10 | |
| Lobster, canned | 18 | 1.02 | |
| Butter | 20 | 20.00 | |
| Do | 25 | 25.00 | |
| Do | 30 | 30.00 | |
| Eggs, 36 cents per dozen | 24 | 2.09 | |
| Eggs, 24 cents per dozen | 16 | 1.39 | |
| Eggs, 12 cents per dozen | 8 | .70 | |
| Cheese | 16 | .64 | |
| Milk, 7 cents per quart | 3½ | 1.09 | |

fourth column in Table V shows the total weight of each food
al and the last four columns the amounts of different nutrients
energy that can be obtained for 10 cents when the price per
is that given in the first column. Chart 2 illustrates graphically
ts brought out in this part of the table.

CHART 2.—PECUNIARY ECONOMY OF FOOD.

*nts of actually nutritive ingredients obtained in different food materials for 10 cents.*

[Amounts of nutrients in pounds; fuel value in calories.]



is taken of the cost of cooking or of the convenience of p
the table, which are sometimes even more important fr
point of actual economy than the market prices.

The figures of Table V show, for instance, that 10 c
beef sirloin at 20 cents a pound buys 0.5 pound of mea
tains 0.08 pound of protein, 0.08 pound of fat, and 515 calo
actually available to the body, while the same amount sp
at 35 cents a quart would buy a little over half a pound o
taining 0.03 pound of protein, 0.01 pound of fat, 0.02 po
hydrates, and 125 calories of energy; or if spent for c
cents a pound, it would buy 4 pounds, containing 0.05
tein, 0.01 pound of fat, 0.18 pound of carbohydrates, an
of energy, while of wheat flour at 3 cents a pound it
pounds, containing 0.32 pound of protein, 0.03 poun
pounds of carbohydrates, and 5,410 calories of energy
the various materials in this way, it becomes clear that t
tables are the dearest sources of protein, meats and f
cheaper, and the cereals cheapest of all; and that oyster
are the costliest sources of energy, followed by some of th
tables and fruits, then the majority of the meats, next
cheapest of all, the cereals.

It is quite evident that the market price of food ma
regulated by their actual value for nutriment. For insta
of protein or fat from the tenderloin of beef is no more n
that from a round or shoulder, but it costs considerabl
agreeableness of food to the palate or to the buyer's fanc
do in deciding current demand and consequent selling p

'hat more for the same total quantity of nutritive material in imal food.

point to be especially noted here is the difference in the cost of nts in foods already prepared for use and in the same materials prepared. For instance, wheat made into ordinary prepared ast cereal might contain no more available protein or energy he same wheat made into white or graham flour, but the break- reals cost more than the flour per pound. At the same time, eakfast foods afford a pleasing variety in the diet, and often e little or no cooking and are therefore very convenient; while ur must be made into bread or other food at more expense of fuel, etc. If the breakfast cereal does not cost much more than ur the difference may be offset by the convenience of prepara- r the table, the palatability, and the pleasing variety it gives. y of the breakfast foods are advertised as having an especially utritive value. If the statements often made in advertising could be believed they would have some nutritive property not in flours and meals ground from the same grains. For these there is no ground. The breakfast foods made from wheat, ats, and other cereals contain no nutritive material other than 'hich is in the original grain, and which is also found in the ordi- lours and meals made from the same grains; and when the two of food are equally well cooked there is no experimental evidence w any difference in the thoroughness of digestibility. The retail of the breakfast foods are from two to five times as large as of the ordinary products, like flour and meal. The advertise- , which often claim nutritive values that are fictitious, do not ny suggestion of the high price of the nutrients in the prepared as compared with that of the same amounts in the ordinary cts, nor do purchasers generally realize how expensive these pre- foods are.

## ERRORS IN FOOD ECONOMY.

ntific research, interpreting the observations of practical life, tes that a fourfold mistake in food economy is very commonly First, the costlier kinds of food are used when the less expen- e just as nutritious and can be made nearly or quite as palatable. lly, the diet is apt to be one-sided, in that foods are used which h relatively too much of the fuel ingredients and too little of the orming materials. Thirdly, excessive quantities of food are part of the excess is eaten and often to the detriment of health; thrown away in the table and kitchen wastes. Finally, serious in cooking are committed.

the well-to-do the worst injury is that to health; but people of ncomes suffer the additional disadvantage of the injury to purse.

This is often done under the impression that there is s
virtue in the costlier materials and that economy in the
mental to dignity and welfare. Unfortunately it is too c
that those who are most extravagant in this respect are
can least afford it. On the other hand, there is freque
to economize, but a lack of knowledge of the best metho
Many a housekeeper who sincerely tries to do the best fo
provided for, but whose every cent must tell, buys eggs
dozen, or sirloin steak at 20 cents a pound, when, for the
of money, it would be possible to get twice as much nour
a cheaper cut of meat, which, with a little skill in pre
cooking, could be made into a tasty dish such as person
circumstances would not hesitate to set upon their tabl

The difficulty is the ignorance of the simple principles
That ignorance results in a great waste of money. The
the best is the cheapest," as popularly understood to
higher-priced materials, is not true of food. The large
price of the costlier foods is paid for appearance, flav
While the dearer articles are often more pleasing to th
are sometimes more easily cooked or possess a finer fla
no more digestible nor nutritious than the cheaper ones.
can afford them may be justified in buying them, but f
good health and with limited means they are not economi
increase the cost of food out of all proportion to nutrien

In the course of some dietary studies made in one of th
tricts of Chicago it was found that a woman, whose hus
of work and whose family was living on a few cents a
lettuce, an article so innutritious that, at least when c
and high in price, it is a luxury even for the rich, while s

home. The remedy for this evil will be found in an understanding the elementary facts regarding food and nutrition, in a better owledge of cooking and serving food, and in the acceptance of the ctrine that economy is not only respectable but honorable.

The soup kitchens which have been established in many cities, ere meals planned according to accepted dietary standards are sold very low and yet profitable rates, should furnish their patrons with ject lessons on the food-purchasing power of money.

### DANGER OF A ONE-SIDED DIET.

Unless care is exercised in selecting food a diet may result which is e-sided or badly balanced—that is, one in which either protein or l ingredients are provided in excess. If a person consumes large ounts of meat and little vegetable food, the diet will be too rich in tein and may be harmful. On the other hand, if pastry, butter, such foods are eaten in preference to a more varied diet, the food furnish too much energy and too little building material.

xtreme illustrations of such a one-sided diet are found in the food hose persons who live largely on bread and tea, or others who live corn meal, fat pork, and molasses. The "hog and hominy" diet plies liberal quantities of energy, but is very deficient in protein, llustrated by the diet of negroes in the "black belt," with 62 grams rotein and 3,270 calories of energy per man per day.

n this connection it should be said that most of our dietary stands have been deduced from food investigations conducted with pers living in temperate climates. It is not improbable that those ng in arctic regions and in the Tropics require nutrients in different portions. It is a matter of common observation that in arctic ions much larger amounts of energy-yielding material, principally are consumed than in warmer climates. Less definite informan is available regarding food requirements in the Tropics; but it ms probable that when proper dietary conditions are followed someat less food is consumed than in temperate regions, and that the trients are in somewhat different proportion. It is certain that a t which would be entirely satisfactory in frigid regions would be e-sided in the Tropics, and vice versa. This subject is one which eds further investigation before definite conclusions can be drawn garding the foods best fitted for extremes of heat or cold.

### WASTE OF FOOD.

The use of excessive quantities of food, which is a common dietary ror in this country, among not only the well to do but also those in derate circumstances, entails a waste of food in at least three ways: First. More food is eaten than can be properly utilized by the body. is is not universally true, for there are some people who do not eat ough for healthful nourishment. But the eating habits of large mbers are vicious, resulting not only in a loss of food material but an increase in the labor of digestion, to say nothing of the injurious equally comfortable circumstances.

Third. The third form is that which occurs in the p
food materials for consumption. Thus, in removing the
rial, as skin, seeds, etc., from fruits and vegetables, m
the edible portion is removed also, depending upon
which the work is done. The greatest loss from a pec
point, however, is in the waste of animal foods in which th
in their costliest forms. The "trimmings" of meat whic
the butcher or removed in the kitchen frequently contain
the nutritive ingredients of the material paid for. Part
is inevitable, but much of the valuable nutrients might
materials were used for making soup. The more econ
meats are those in which there is less waste of this kind;
meat as loin of beef, rib chops of lamb, and similar cuts
cost goes to pay for bone. Such cuts, therefore, shou
by those who wish to get the most actual nutriment fo

Just where and among what classes of people the w
greatest it is not possible to say, but there is certainl
more of it in this country than in Europe. The worst
it are doubtless the poor, but the large body of peopl
means, the intelligent, and fairly well-to-do wage-worke
errors in this regard. The common remark that "the a
ican family wastes as much food as a French family wou
is greatly exaggerated, but statistics show that there i
truth in it. In dietary studies conducted at a studen
Eastern college it was found that 10 to 14 per cent of
materials purchased were thrown away as kitchen or ta

substantial improvement of their household economics two things needed. They must be informed as to the high nutritive value of cheaper foods as compared with the costlier kinds, and the meth- s of cooking must be improved. A great deal of fuel is wasted in the eparation of food, and even then a great deal of the food is badly oked. To replace dear food badly cooked by cheaper food well oked is important for both health and purse. To make the table re attractive will be an efficient means for making the home life re enjoyable.

## SUMMARY.

Food has been briefly defined as "that which taken into the body, her builds tissue or yields energy." In its building function pro- n is the most important ingredient of food, as it is the basis of mus- , bone, and almost all the tissues and fluids of the body. Mineral atters are also needed in the body structure, though in smaller quan- ies. Protein, fats, and carbohydrates may any of them be burned the body to produce heat or muscular energy, but for protein this a less important and probably less usual function. The fats and rbohydrates, by being themselves used as fuel, leave the protein for indispensable work of tissue forming.

Not only the amounts of nutritive ingredients which a food contains, t also the proportions which can be digested and utilized by the dy, determine the real nutritive value of a food material. As a neral rule, carbohydrates are more completely digested and hence ore fully available for use in the body than protein and fats, and otein of animal foods, as meat, fish, milk, and eggs, is more digest- e than that of vegetable foods. Fats are probablly less digestible an most forms of protein and carbohydrates.

In ordinary mixed diet the chief sources of protein are meat, fish, d milk among animal foods, and the cereals and legumes among getable foods. Beans, peas, and oatmeal are rich in protein and nce especially valuable food. About nine-tenths of the fat in the dinary diet is obtained from the animal foods, while the vegetable ods furnish approximately nine-tenths of the carbohydrates.

Other things being equal, foods furnishing nutrients which can be ost easily and completely utilized by the body are the most desirable, nce they will not bring unnecessary exertion to the various organs. any kinds of food which in their natural state hold the most valuable utrients in such form that the digestive juices can not easily work pon them are so changed by the heat of cooking that they become asily digestible. Thus the importance of proper cooking can hardly e overestimated. Things which please the palate stimulate the flow f the digestive juices; for this reason food should be made appetizing. n attractive diet pleases the æsthetic sense; hence refinement in food

some of animal, some of vegetable origin. With a varie
easier to secure the proper proportions of protein to fats
drates.

As the habits and conditions of individuals differ,
needs for nourishment differ, and their food should be ac
particular requirements. It has been estimated that ar
at moderately active labor, like a carpenter or mason
about 115 grams or 0.25 pound of available protein and
ingredients in addition to make the fuel value of the wl
calories, while a man at sedentary employment would
ished with 92 grams or 0.20 pound of available protei
fats and carbohydrates in addition to yield 2,700 calo
The demands are, however, variable, increasing or de
increase or decrease of muscular work, or as other needs
change. Each person, too, should learn by experience
food yield him nourishment with the least discomfor
avoid those which do not "agree" with him.

Too much food is as bad as too little and occasions a w
and strength in the body as well as a waste of nutri
While in the case of some foods as purchased, notabl
waste is unavoidable, the pecuniary loss can be dimini
buying those kinds in which there is the least waste, ar
more carefully than is ordinarily done portions of w
classed as refuse. Much of the waste may be avoided b
ning so as to provide a comfortable and appetizing me
amount, but without excess. If strict economy is necess
cuts of meat and the more expensive fruits and vegeta
avoided. With reasonable care in cooking and serving,

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